Ball lightning as an optical incoherent space spherical soliton

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Introduction

“Ball Lightning: An Unsolved Problem in Atmospheric Physics” is a title of the last monograph published in 1999 [1]. We would like to refine this assertion and declare that Ball Lightning (BL) is a shame of physics today. At present above 2000 papers and reports have been published, above 200 various BL theories linking BL to a variety of physical, chemical and nuclear processes have been proposed but none of these theories seems to have gained a general

recognition because they fail to explain all observed characteristics of the phenomenon. A regular appearance of new theories confirms this conclusion, and new theories are not exception. Systematization and classification of theories have been carried out. However neither of them even approximately can explain enigmatic and intriguing BL behaviour, which in a certain degree reminds behaviour of some highly organized matter. Physicists cannot imagine the object, governed by conventional physicist laws, properties of which coincide with BL properties. Explanation of Ball Lightning physics is deadlocked.

In 1838, French scientist Arago published the first survey of twenty reports of ball lightning. After sixteen years of investigation he wrote in 1854 “The Ball Lightnings of which I have cited so many examples, and which are so remarkable, first for slowness and uncertainty of their movements, and next for the extent of the damage which they cause in exploding, appear to me to be one of the most inexplicable problem of physics today. These balls or globes of fire seem to be agglomerations of ponderable substances, strongly impregnated with the matter of lightning. How are such agglomerations formed? In what region do they originate? Whence are delivered the substances of which they are composed? What is their nature? Why do they sometimes pause for some time in their course, and afterwards they rash off with great rapidity? In the face of these questions, science remains silent”. At present once 154 years have been passed, scientists can answer no one of the put questions in that time. Moreover, prospects of a solution of BL nature are foggiest if new ideas will not be offered. It is extremely difficult to propose them because all conceivable hypotheses are already have been proposed, considered and recognized inconsistent.

As noted Robert Matthews, a reporter of widely-known journal New Scientist, a Ball Lightning is a flying bag of paradoxes. “It glows like a 100-watt light bulb, yet has no obvious power supply. People say it is linked to thunderstorms but it has rarely been linked to a lightning strike. It emits little heat, yet can melt glass window. It floats like a ball of gas, yet hangs together like a blob of liquid. To have a hope of explaining the mystery of ball lightning you must first square all these circles” [2]. Really, it is impossible to imagine an independent isolated object which could feel and bypass obstacles, penetrate into a room through window panes and narrow cracks, changing thus its form, could move against a wind, could accompany flying airplanes and to not be blown off by a stream of the air which speed is greater than that in the strongest hurricane. This object radiates the cold white light which does not burn down, unlike the white light radiated by any body heated up to several thousands degrees.

A criterion which enables to evaluate various hypotheses is very simple. Really, as BL can penetrate through glass, BL should consist of substance which can penetrate through glass. Such substance cannot consist of particles, as any particles (electrons, ions, atoms, molecules, clusters, motes, etc.) cannot penetrate through glass. We can conclude that BL has no weight because only particles are ponderable. The same conclusion can be derived from the fact that BL can move against a wind. It is not required to be a prominent physicist to understand that any particles should be carried away by the wind in spite of any inner processes within BL. According to this criterion almost all existing hypotheses should be rejected. The exception is not provided by the most popular at present day BL theory of Abrahamson and Dinnis [3]. They proposed that BL is due to oxidation of silicon nano-particles in the atmosphere. The silicon nano-particles are formed as a result of a reaction of silicon oxides and carbon in the soil during a lightning strike. Exceptions are the hypotheses in which BL occurrence is connected with a presence of external fields and BL represents some discharge in the place where a concentration of these fields takes place [4]. However these hypotheses failed to explain BL behaviour which is determined by the objects surrounding it rather than hypothetical external fields.

Electromagnetic radiation satisfies first of all to this criterion. Such radiation in a form of light waves can penetrate through windowpanes. Windows are fabricated specially from glass which provides a penetration of light in a room. Radiation is not blown off by a wind. The light

beam propagates rectilinearly in an atmosphere. It can be bent in the direction where the refractive index of an optical medium increases rather than in the direction of wind. This explains occurrence of mirages in deserts. Speed of light is extremely great. Because of this light is indifferent for the speed at which an object moves. For example, the speed of an airplane is smaller than that of light by a factor of one million.

It is impossible to imagine that light radiation can be concentrated in some limited volumes which sizes are equal to BL ones without a help of any particles. It is true, but ball lightning exists in air atmosphere where molecules of air in excess. It turns out that it is possible in this case. To avoid immediate rejection of this assertion it is worthwhile to tell a story how this conclusion was derived. Having prepared an application for a grant, we considered ways of protection of optical resonators of whispering gallery type from a harmful influence of moisture in air on their surface that led to an appreciable decrease in their quality factor. Such resonator represents a glass ball of a fraction millimeter in diameter in which the resonance for a traveling wave of whispering gallery type takes place. Such wave can be imagined as a light wave which circulates inside the ball along its equator. The wave cannot leave the ball because of the phenomenon of total internal reflection on the border between glass and air. Such resonators are characterized by extremely high quality factor Q [5].

The quality factor of such resonator in first minutes after manufacturing is equal about Q=10^{10}, and decreases by a factor of 1-2 orders of magnitude in some hours because of the degradation of the ball surface caused by a harmful influence of moisture in the air surrounding the ball. It is known how this phenomenon can be overcome. The similar problem existed in fibers widely used now in telecommunication for high-speed transmission of optical signals at great distances. A fiber was initially a glass thread along which a light entered into its end face could propagate. The light does not leave the fiber because of the phenomenon of total internal reflection on the border between glass and air. However there was a degradation of the fiber surface in time. Now fibers consist of a glass core where a light propagates. The core is coved by a glass coating which protects the core from degradation. The same phenomenon of the total internal reflection on the border between the coating and core takes place if the refractive index of the coating is a little bit less than that of the core. For fibers the difference of these parameters can be less than 1 %. Using this recipe we considered a glass ball as a core. We surrounded it in our imagination with a spherical glass coating which refractive index is smaller than that of the ball. Having calculated a necessary minimal difference in refractive indexes of the ball and the coating surrounding it, we had found out that this difference can be less than 1% for a ball of several centimeters in diameter.

As the field of a light wave is concentrated near a ball surface, it is sufficient to fabricate in a homogeneous glass a spherical layer of several centimeters in diameter and several microns in thickness where the refractive index is greater by 1 % than that of the homogeneous glass. The layer will confine the light entered into it in the same way as a light is confined by a fiber core. There is an unresolved problem how the light can be introduced into the layer. Unlike fiber, where an end face can be used for this purpose, such end face is absent in the spherical layer.

Then we have recollected that there are optical spatial solitons in the nature. Such soliton can be imagined as a rectangular beam of a monochrome light propagating in a homogeneous nonlinear optical medium which refractive index increases with an increase in the light intensity. The thickness w of the beam is comparable with the light wavelength and the width of the beam is close to infinity. In process of propagation of the beam its thickness w tends to a steady state and a distribution of the light intensity along the thickness is proportional $\mathrm{Ch}^{-2}(x/w)$ where the x-axis is parallel to the direction along which the thickness is measured. It has been shown that the steady state is stable. At a deviation of w from its steady-state w comes back to a steady state in process of propagation of the beam. Unlike a usual light beam, diffractive divergence is completely absent in the soliton. It is possible to tell that an intensive plane light beam, propagating in a

homogeneous nonlinear optical medium, forms a planar optical waveguide which confines the beam divergence. Thus an optical spatial soliton can be considered as a planar optical lightguide formed by a plane light beam in a homogeneous **nonlinear** optical medium [6].

As for an incoherent spatial optical solitons, they are a generalization of coherent ones. Unlike conventional coherent solitons, incoherent spatial optical solitons are formed by a plane beam of incoherent light. However an incoherent soliton also forms a planar optical lightguide which provides steady-state width of the incoherent light beam. An interest to incoherent optical spatial solitons has arisen rather recently in the end of 20 century, especially after experimental acknowledgements of their existence [7, 8, 9]. Like conventional optical space soliton, an incoherent optical space soliton can be considered as a planar waveguide which refractive index is greater than that of surrounding medium. In this case an intense light forms a planar waveguide which confines the same light.

Any "lightguide" can guide light as it follows from literal understanding of this word. For example, a fiber is an optical lightguide which guides a light along its axis. If a fiber is rolled on a finger, a light will propagate along the fiber, i. e. along a spiral trajectory. Similarly, if a planar optical lightguide fabricated in a homogeneous optical **linear** medium by means of an increase in the refractive index in a planar layer of *w* thickness is bent, the light will continue to propagate in the bent lightguide along a curved trajectory. Similarly, if a planar optical lightguide fabricated in a homogeneous optical **nonlinear** medium by means of an intense planar light beam of *w* thickness (space soliton) is bent, the light will continue to propagate in the bent lightguide along a curved trajectory.

It is clear that the bent lightguide formed by the intense bent light beam is instable because the beam tends to propagate rectilinearly rather than along the bent waveguide and the beam will change the lightguide curvature. But in this case the following interesting theoretical problem arises. What would happen if the curvature of a plane spatial soliton becomes distinct from zero in the whole layer? As far as the soliton form is concerned, an answer is simple enough. If the curvature has been changed along one direction only in parallel with the direction of light propagation, the plane soliton is transformed into cylindrical one. If curvature is changed in two mutually perpendicular directions, the plane soliton is transformed into spherical one. There were strong doubts about stability of such incoherent optical space spherical soliton (IOSSS). Besides, it is not clearly absolutely how initial conditions in a homogeneous nonlinear optical medium can be obtained. Because of this till some time we believed that results of similar researches cannot be checked up experimentally and, therefore, it is not meaningful to be engaged in such research.

Later an idea has come that if IOSSSs can exist, probably they could be observed in the nature. Thus it has been paid attention to Ball Lightnings (BL). As follows from their name, their form is spherical and they are connected with white light as they are visible owing to the light radiated by them. A conventional atmosphere air can be considered as a nonlinear optical medium. Indeed, the air refractive index increases with increasing the air density which in turn is proportional to the air pressure. Due to the optical phenomenon of the electrostriction pressure an intense light propagating in an air exerts the additional air pressure which is proportional to the light intensity. As a result, the air refractive index increases with an increase in the light intensity and, therefore, the air is a nonlinear optical medium. In this case an IOSSS can be imagined as a light bubble reminding a soap bubble. However instead of a soap film there is a thin film of a strongly compressed air. The intensive white light circulates in the film in all possible directions and produces the excess air pressure in the film due to the electrostrictive effect. The refractive index of the film is greater than that of surrounding space. The film manifests itself as a planar lightguide which curvature is different from zero. The light, introduced in such film, can propagate within it in all possible directions but it remains in the film and is not emitted into surrounding space. Thus, IOSSS is a combination of an intense light and a film of air compressed

by the light. The compressed air provides a circulation of the light in the film. The circulating light, in its turn, provides the air compression. It can be said that IOSSS is a self-confined light circulating in a thin spherical layer of compressed air which is produced by the same light. In other words, the light circulates in a spherical trap, which was set up by the same light. In this paragraph the physical nature of IOSSS in conventional air atmosphere is described completely.

We in the first place have tried to investigate theoretically IOSSS behaviour in the usual terrestrial atmosphere. To our great surprise IOSSS behaviour has coincided with intriguing and mysterious BL behaviour. From here on an abbreviation BL will be used for a designation of real Ball Lightnings which properties are known from numerous evidence of eyewitnesses, and IOSSS for a designation of abstract light bubbles which exist in our imagination only and which properties can be investigated theoretically. Since in accordance with our approach Ball Lightning is a self-confined light of spherical form, we can cut a tail in a word Lightning and name Ball Lightning by Ball Light. Thus, IOSSS and light bubble are synonyms as well as BL, Ball Lightning and Ball Light are.

In the first chapter IOSSS behaviour in real conditions of earth atmosphere is considered. It is shown that in accordance with well-known physical and optical laws IOSSS behavior exactly corresponds to all features of BL one. Authors hope that after reading this chapter a reader will have no doubts about validity of the hypothesis because too many BL features can be explained in a perfectly natural way. All of these explanations are collected in one place in order to convince a reader in a validity of the proposed approach.

It would be possible to finish studying an interrelation between BL and IOSSS by the first chapter and to wait when the presented hypothesis will win a general recognition. But there was a unique situation for authors. Unlike others they knew that IOSSSs do exist in nature. It would be silly to ignore this advantage. In first, results of two-century investigations at attempts to produce an artificial BL in a laboratory have been analyzed. It turned out that various luminous objects have been produced by many experimenters. In 19 century similar objects did not exist autonomously. They disappeared at once after ceasing a gas discharge. In 20 century experimenters succeeded to produce objects which can exist autonomously in several seconds. At present time similar objects can exist about 10 seconds after ceasing a gas discharge. This time is comparable with the life time of many BLs. Investigators differently name the objects observed by them. Among these names were such as long-lived luminescent objects, ball-shaped plasma formations, the exotic vacuum objects, the spherical anomalous objects, luminescent ball-shaped objects, the abnormal anomalous objects, abnormal plasma formation etc. We will name shortly these objects as anomalous objects (AO). On assumption that AOs are miniature IOSSSs with relatively small lifetime and small stored energy we succeeded to explain AO behavior in many experiments. Results of these studies are presented in [10]. Unlike BLs, which properties are accessible from evidence of eyewitnesses only because it is a seldom enough natural phenomenon, AO properties can be studied carefully in a laboratory. An analysis of these properties on the assumption AO is OISSS enabled us to discover and justify several new optical effects. Firstly, an analysis of AO spectrums prompted that alongside with Kerr-like and electrostriction nonlinearities there is a new type of nonlinearity in nature. The nonlinearity takes place in gas mixtures and manifests itself by adsorption of molecules of the mixture component with maximal refractive index in the field where an intense light beam is propagating [11, 12]. This type of nonlinearity is stronger essentially than that of nonlinearities mentioned above.

An analysis of possible mechanisms responsible for AO appearance enabled to conclude that an intense light in a gas is subjected to self-organization. [13]. Like a saturated vapor with a decrease in its temperature is converted in a mist, consisting of drops of liquid, an intense light and gas are converted in a majority of AOs with an increase in the light intensity. This effect changes radically Kirchhoff's notions about properties of equilibrium light radiation. At great

enough light intensity in a gas a state of equilibrium is impossible because of a self-organization of the intense light. Since the BL nature became known, attempts had been undertaken to consider mechanisms of its appearance. Results of these studies are presented in [14, 15].

Thus, having accepted a priori, that IOSSS exist in the nature, and having learned in theory their behaviour in accordance with conventional physicist laws, we were be able to conclude that IOSSS properties and behaviour peculiarities are similar to BL and AO ones. This gave solid grounds to argue that IOSSSs exist in the nature as a matter of fact.

It was a much more difficult task to justify IOSSS existence theoretically. Apparently, such conclusion looks like extravagant. Indeed, it is very hard to believe that a conventional white light can be self-confined by usual air in such a way that it is circulating in a shell of several centimeters in diameter. The common sense protests against it. Authors were forced to overcome a series of irrefutable and indisputable, at first sight, arguments that the IOSSS not can exist in principle. They were forced to justify a possibility of light to circulate into the air along trajectories with a small curvature radius [16], stability of IOSSS [17], their extraordinarily large lifetime [18]. The nature of electrostriction pressure exerted by intense light in gases has been investigated anew in detail.

At present many physicists are very interesting in this approach. Above dozen of scientific peer review papers have been published in international physical journals such as Doclady Physics, Physics Letters A, Optics Communication, European Physical This activity has been carried out in frame of conventional physical notions and laws in conditions when positive answer is known in advance and it is only necessary to find a solution. Certainly, the confidence in a positive final of researches has promoted their success. The authors had no purpose to elaborate a model of ball lightning which could be used as a basic argument confirming the validities of chosen approach because any model is a fine target for critique. Indeed, in any model it is impossible to take to into consideration all variety of phenomena of the real world. The task was more modest. It was necessary to disprove major objections which were expressed by physicists more often. The basic argument confirmed a validity of the approach is not theoretical conclusions, but the dramatic coincidence of BL and IOSSS properties.

After there was a confidence that IOSSS exist in the nature there was a lawful question - whether there can be similar IOSSSs in other phenomena accompanied by wave processes. Since the energy stored in IOSSS is gradually decreasing due to inevitable radiating losses inherent in waves of whispering gallery type, the IOSSS lifetime is definite. IOSSS ceases its existence abruptly. Similar situation takes place for nuclei of chemical elements which, as is known, are subjected to a radioactive decay. In this connection it is interesting to consider a hypothesis where a nucleus is presented by a certain space spherical soliton (SSS). As is known, a nucleus is described by a wave function which satisfies a wave equation. Like incoherent optical SSS where light waves of whispering gallery type is circulating, waves of the same type but presented by a wave function can circulate in a nucleus. In this case a nucleus can be imagined as an oscillator with an extremely high quality factor. Very valuable property of such oscillator is its ability to store and accumulate an action produced by other similar oscillators. In principle, such ability permits to obtain a noticeable result in process of week but prolonged interaction between nuclei. In chapter 2 properties of a system consisting of a majority of identical oscillators interacting one with other are considered. On the basis of rather general assumptions conditions are found, at which a week but prolonged interaction can result noticeable change in parameters of some oscillators. These results enabled to formulate conditions favorable for an increase in the speed of radioactive decay. Numerous experimental data confirmed these results are presented.

Five years ago authors knew nothing either about Ball Lightnings, or about radioactive decay. Having shown curiosity and asked by a simple question - whether there can be self-confined light in the form of a light bubble in a homogeneous nonlinear optical medium, authors

have plunged into the world of the abnormal phenomena which collected in centuries. It has appeared that many of these phenomena can be explained with attraction of the concept of light bubbles. Researches have been lead under the personal initiative of authors. All ideas and conclusions reflect their personal opinion.

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Behavior of optical incoherent space spherical solitons in atmosphere

Abstract

On assumption that optical incoherent space spherical solitons in a form of light bubbles can exist and their shell, unlike soap bubbles, consists of strongly compressed air where an intense white light is circulating in all possible directions, a behavior of such bubbles in the conventional air atmosphere is considered. It is shown that a bubble, like a usual light beam, should be deflected in the direction of the air refractive index gradient where the bubble is located. Distributions of the gradient in various situations which took place at observations of Ball Lightnings are considered. It is shown that the distribution of the gradient in all these cases is so that a simple and natural explanation of Ball Lightning behavior near the earth surface, moving in a horizontal direction, moving against a wind, penetration in rooms and so on is possible. Thus, the physical parameter which controls a Ball Lightning motion is found out. Authors hope that a reader looses all doubts after reading this chapter that there are light bubbles in nature and Ball Lightnings are their experimental confirmation.

Taking into account that BL represents a light bubble (LB), consisting of a thin layer of strongly compressed air (shell) where an intensive light circulates in all possible directions (figure 1), we shall consider behaviour of such bubble in the conventional air atmosphere. The motionless LB in a homogeneous atmosphere remains motionless. Really, the central symmetry of the system in this case takes place, and there is no selected direction. If LB is located in an inhomogeneous atmosphere where the refractive index *n* depends on spatial coordinates, the situation varies. As the light beam, propagating in an inhomogeneous medium bends in the direction of the gradient of the refractive index, any closed light beam circulating within the LB shell tends to be shifted in the same direction. In other words, LB tends to move there where the density of air is greater. LB is the most sensitive device of inhomogeneity of the air density (provided that other parameters of air in all points of considered space are homogeneous). Really, under assumption that the light circulating in LB shifts per one revolution only at 1 micrometer, its shift per one second is about one kilometer. It is explained by the extremely great light speed of 3 10^8 km/s. For example, if the length of LB circumference is equal 30 cm, light will make one billion revolutions per one second. Billion shifts by one micrometer makes total shift in 1 km.

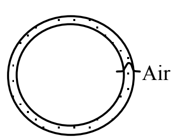


Figure 1. Light

There are no BL theories which can explain an extremely simple thing. What are reasons, which force BL moves in such a way in which BL moves? For example, we can read in [1]. “In the author’s model electrostatic repulsion is invoked partly to explain why balls falling from the cloud base and therefore obviously heavier than air, so frequently stop before they hit the ground”. Our explanation is very simple and natural. There is no gravity attraction to the ground, or to be more precisely, forces of gravitation are inessential. As is known the air pressure decreases with an increase in the height. Therefore, the air density and air refractive index decrease with increase in the height. Since LB moves along the gradient of the refractive index, LB moves downwards to the ground surface until the above mentioned dependence of the refractive index on the height is hold. But LB does not achieve the ground surface. The reason is in the temperature of ground surface which absorbs a sun radiation. Because of heating, the temperature of the ground surface is greater than that of the air near it. Because of the air heat conduction, the air temperature of a layer near the ground surface is greater than that of layer resides at greater distance from the ground surface. Since the air density is in inverse proportion with the air temperature, the air density near the ground

surface is smaller than that of the layer located at greater distance from the ground surface. As a result, there is the maximum of the air density at some height h. This height is about 1 m. Achieving this maximum, LB stops motion along the height and moves along the horizontal component of the air density gradient or the air refractive index gradient (directions of these gradients coincide). That is why observable BLs move mainly at a small height in a horizontal direction. Remind to a reader that antifog headlights at cars aspire to arrange as close to the earth surface as possible. The air temperature near the earth surface is maximal and a fog is not formed at such temperature. Therefore low located antifog headlight gives light beam penetrating at greater distance.

Moving in horizontal direction, LB itself can change distribution of the air density around itself, especially at approach to obstacles. If air pressure is homogeneous, the air density is in inverse proportion to the air temperature, therefore LB moves in the direction opposite to the temperature gradient. Coming nearer to some obstacle, LB heats up it due to radiation. In turn, the obstacle heats up the air surrounding it and thus decreases the air refractive index. Gradient of the refractive index directed from the obstacle appears. Moving along this gradient, LB jumps aside from the obstacle or bypasses it. Externally it looks like as if LB would "feel" the obstacle and bypass it.

As is known, falling BLs are observed more often approximately by 10 times than rising ones [2]. It speaks that the gradient of the refractive is directed downward in a typical atmosphere. However air temperature can be different e in different places of space and, hence, different air density at the same pressure is possible. In particular, an inverse distribution of the air density along the height is possible where LB will move upwards.

How soliton finds out holes, splits, chimneys to penetrate through

There are a lot of evidence that BLs can penetrate in rooms through small cracks and splits. We present some of them taken from the Stakhanov book [3].

During strong thunderstorm BL of 20-30 cm in a diameter entered a room through a hole for grounding in a wall.

During thunderstorm BL of 10 cm diameter passed in a hole of 2 cm width, "having taken form a sausage".

BL penetrated through a crack in a windowpane. BL diameter was about 10-20 cm.

BL of 30-50cm diameter entered through a small hole in a window (the beaten off corner of glass) of 1-1.5 cm width in a form of «a yellow thread ". Having done some circles around a room, it is blown up through 20-30 s.

BL of 5-10 cm diameter has entered "by snake" during a thunderstorm through the slightly opened window leaf, having formed then a ball. Having passed in a room a distance of 5-10 m, it has disappeared without explosion near a switch.

During strong thunderstorm BL has entered into the house in a split between boards near a chimney tube, thus the board was smoked, there was a fire.

BL of 10-20 cm diameter has passed through a hole of 8 cm diameter.

BL of "tennis ball size" has passed through the closed window with a crack in the glass.

BL "flows" in a hole between logs in a smithy. The width of the hole was much less than BL size. In the smithy it looked like a sphere of 12-13 cm diameter of orange color and shone as a 50-100 W lamp.

In a crack in a wall a yellow ball of size about a large orange squeezed. More truly, it did not squeeze, but it was poured from one half in another.

BL has passed in a room in a hole in glass, having flattened as its size was greater than the hole. Eyewitnesses specify: «The sphere was in 10-15 cm from our faces, and we well saw, how it began to pass through a hole, taking the form of a melon. It was extended, became smaller in diameter and has passed through the hole. When the sphere was passing through the hole and was decreasing in its sizes, it as though was shivering all time, and it seemed, that it consists of galley ".

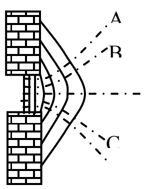


Figure 2. Distributio

Before analysis of the mechanisms providing penetration BL through small cracks and holes, we should answer a simpler question - how does a soliton find similar objects? In general, why a soliton is not indifferent to cracks and holes? Clearly, that the soliton has no organs of sense, vision, sense of touch that are in living being. However the soliton can "feel" the slightest changes in the air refractive index and moves along the refractive index gradient. We shall show that cracks are sources of such changes.

Consider a soliton movement in a tunnel shown in figure 2 between a room (left hand side in figure) and external space (right hand side). Let the temperature indoor is smaller than that outdoor, and the air pressures indoor and outdoor are identical. In this case the indoor air density is greater, than that outdoor and the gradient of the refractive index at the tunnel axis is directed to the room. As the air density along the tunnel changes gradually and continuously, surfaces of identical density look like solid lines shown in figure 2. Dashed lines in the figure are perpendicular to these solid lines. The direction of a tangent to any of these dashed lines in any point coincides with a direction of the refractive index gradient in this point. It is easy may be convinced, that a soliton, moving along any dashed line from various points A, B, C, moves in a direction to the tunnel. A peculiar funnel appears near the tunnel. Having got in the funnel, a soliton moves in a direction to the tunnel.

In the same manner solitons find out chimneys on roofs of buildings to penetrate through the chimneys in rooms. There is a funnel near each chimney. Dropping downwards, LB meets one of such funnels at its way and begins its motion as is described in the next section. Ought to note the summary area of cross sections of all funnels on any roof is significantly greater than the summary area of cross sections of all chimneys. What is why a probability to penetrate into a chimney is great enough. At least, the probability is greater than that for rain drops because there are no funnels for them.

How soliton penetrates in a room through a small split

It is interesting also how a soliton determines the size of the tunnel cross-section (hole) and deforms itself in such a way that it can penetrate in the hole. To answer the question, ought to consider the reasons that provide a spherical form for the soliton in a homogeneous air and deform the soliton in an inhomogeneous air. The air pressure within soliton is great enough. But this does not mean that the soliton is similar to a child air balloon which can not be deformed essentially. The air pressure in the soliton exists in a soliton shell only which is a thin layer of several micrometers width. The pressure provides a spherical form for the soliton, but in much smaller degree than the pressure within the whole ball volume as in the child air balloon. This entails that external small forces can deform the soliton significantly. The soliton can be compared with a formless shell of child air balloon located in the weightlessness and vacuum. The shell takes the form of ball because own weak elastic re-established forces of the shell can show themselves in the absence of other strong forces of gravity and the air pressure. These re-established forces tend to straighten the shell. But the shell can not be plane because of its closed form. As a result, the shell ends up as a ball. But this ball is different from a child air pumped balloon. For example, such balloon can not be drawn

through a small ring. The airless shell in the weightlessness with the same spherical form can be equally well drawn through the small ring as the airless shell can be drawn through the small ring in the presence of gravity.

The similar situation takes place for the soliton shell which takes a spherical form in a homogeneous optical medium owing to elastic properties of a layer of air compressed in the soliton shell. A soliton form can be easily changed in the precisely same way as the spherical form of an elastic shell of a balloon is changed in weightlessness and vacuum.

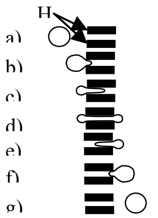


Figure 3 Steps of

As the soliton approaches the hole, inhomogeneity of the air density arises because of heating of the air by the soliton. But the soliton heats the air indirectly. Non-transparent objects should be heated before. Such an object is a region around the hole shown in Figure 3a. The soliton heats the region near the hole denoted by *H* letter in Figure 3a. The region heats the adjacent air on account of the heat conduction phenomena. The nearer the air region the non-transparent surface is, the greater the air temperature. As a result of the heating the air density decreases and forces come into existence that push the soliton surface to from the hot region. On the other hand, there is the air refractive index gradient near the hole axis directed inside the hole. As a result, there are forces near the hole axis that pull the nearest regions of the soliton surface in the hole. These opposite forces entail soliton deformation because own re-established forces of the soliton are week. The soliton form is shown in figure 3b. As the soliton penetrates in the hole, the following feedback comes into force. The smaller the distance between the soliton and the side surface of the tunnel the greater the heating and the greater repulsion of LB from the side surface. Thus, the deformed soliton is located in the middle of the tunnel cross-section as is shown in figure 3c. The next steps of the soliton penetration are shown in figures 3d, 3e, 3f.

Thus, the forces connected with the initial gradient of the air density draw the soliton gradually through the tunnel. The soliton resumes its initial form after the soliton leaves the tunnel at the opposite side of the wall as is shown in figure 3g. One can say that the forces that are responsible for passing the soliton through the tunnel and forces that are responsible for movement of the soliton along the gradient are the same origin. But because of heating the new effect of self-action takes place. The soliton heats the air in such way that the soliton decreases its cross-section and floats through the tunnel in the middle of the hole exactly without touching its side surface. Since the soliton shell thickness is about several micrometers, a soliton can penetrate through very thin slots about of ten micrometers width.

How soliton penetrates in a room through glass window panes

Now it is established reliably, that BL can penetrate through windowpanes, sometimes destroying them, but in most cases leaving their untouched. Damages if they are available have local character and they are in that places through which BL penetrated. In work [4] 42 cases of BL penetration in the closed rooms are described. It is necessary to note, that overwhelming majority of BL theories cannot explain this BL property and for this reason should be rejected. It concerns to all theories in which any particles such as electrons, ions, clusters, as well as plasma are taken into account for explanation of BL nature. As is known, any particles cannot penetrate through glass. Glass tubes and flasks used in chemistry are good confirmation of this. But the light penetrates through the glass. Because of this the glass is used in windows. But a part of the light is absorbed in the glass. The glass can be heated if a very large intense light wave is passing through it. This can cause its damage. There are photos of a glass disk of about 8 cm diameter that was displaced from a window glass after BL penetrated through it. [5].

Soliton finds out windows in the same way as it finds out cracks in walls because the characters of distribution of the air density near windows and cracks are the same. The gradient of the air refractive index is directed to the room in both cases. If the temperature in a room in smaller than outside, the heat penetrates in the room through a windowpane. It is known, that the heat moves in the direction opposite to the temperature gradient. It means that the temperature gradient is directed outdoor from the room. The gradient of the air density is opposite to the temperature gradient and, hence, it is directed to the room. The character of distribution of the air density near a crack shown in figure 2 can be applied also to the window. In this case the crack can be considered as a window of the same form with the glass thickness equaled to zero. Because of this a soliton finds out windows in the same way as it finds out holes.

Penetrating A soliton through a window glass looks like as follows. As is known, a light beam, incident at a plane glass plate, always passes through it. In this case the incident angle α is equal to the angle β at which the beam leaves the plate at its opposite side. The light beam propagates seemingly recliner and cannot return backwards to the soliton. But this is true only if the refractive indexes are the same at the both sides of the glass plate. The refractive index within the soliton is greater than that at the opposite side of the plate where the air pressure is equal to atmosphere one. In this case $\alpha<\beta$ and there is the total inner reflection from the outdoor glass-air boundary at $\alpha\cong 90^0$. Thus, two regimes are possible. The light passes through the glass plate in the first regime and totally reflects in the second one.

When the soliton touches the glass at $\alpha\cong 90^0$, the light penetrates in the plate but the light does not leave it at the opposite side of the glass. The light reflects from the boundary: air-opposite side of the glass on account of the phenomenon of total inner reflection, that is there is a second regime. After the reflection the light enters the soliton shell again. Besides, there is an intense light field in the air near the boundary. The field forms a region near the boundary with the excess air pressure as is shown in figure 4a by letter *P*. As a result, the next portions of light penetrate in the region and it increases in volume as is shown in figure 4b. In this case there is the first regime at the air-glass boundary.

If the densities of atmosphere air are different at the opposite sides of the window glass, then in accordance with the described above effect the soliton moves in that side where the air density is greater. There is impression that the soliton penetrates unobstructed through the glass. In fact, only light penetrates unobstructed through the glass and forms a layer of the compressed air at the opposite side of the glass as is shown in figures 4c, 4d. The compressed air confined by the initial soliton does not penetrate through the glass.

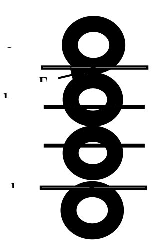


Figure 4. Steps of

Other Puzzles of soliton motion

Usually the homogeneity of air parameters indoor is smaller than that outdoor because an air in a room is mixed in a smaller degree than outdoor. Since a warm air is easier than cool one, the air near a floor is cooler than that near a ceiling and therefore the air refractive index is maximal near the floor. There are much evidence that BL, having got into a room, moves near a floor, but there is no message that BL rises to a ceiling.

There is no problem to explain why a soliton bypasses obstacles. Approaching an obstacle, the soliton heats it due to light radiation. In turn, the obstacle heats a layer of air near it owning the heat conduction and convection phenomena. As a result, the air density near the obstacle decreases and the soliton repelled from it. In this case a LB, appearing in a room, moves towards the floor which shows itself as an obstruction. Besides, walls of the room are cooler than the air in the middle of the room. That is why there is a stove with a chimney in the room. The stove heats air near it and after

then the warm air heats the walls. Approaching a wall, the soliton heats air between the wall and soliton. As a result, its motion towards to the wall ceases and the soliton can move along the wall. Since the air before the soliton is cooler than that behind it, the soliton continues to move along the room perimeter at some distance from walls. In some cases the soliton can find out a door, penetrates though it and leaves the room. There are many evidence supporting this picture.

For example, I. Stakhanov [3] describes in his occasion 29 a closed trajectory BL in a carriage where builders lived. The trajectory is shown in figure 5. Since there is a thermal contact between walls and ground, the temperature of the wall is smaller than that of the air in the room. In this case the air temperature near wall is smaller that that in the middle of the room and the soliton tends towards nearest wall. The soliton heats air near walls and resides at some distance from the wall. Since the air temperature is greater behind the soliton than that in front, the soliton moves along the wall. Meeting a perpendicular wall which prevents its movement in a straight line, the soliton heats the wall. As a result, the soliton turns on 90 degrees. Achieving its entry point and heating the air in the room, the soliton "sees" that the outdoor air is cooler than that in the room. In this case the soliton leaves the room. In some cases the soliton can perform several bypasses along the room perimeter (Stakhanov, evidence number 45). By the way, it is marked in some evidence that some signs of burning on walls are seen.

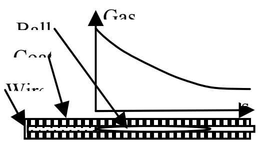
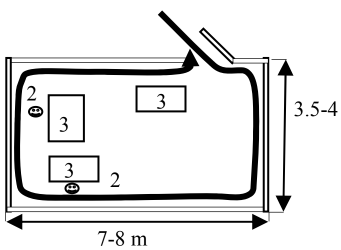


Figure 6. Ball Lightning deformation within the



There are many evidence that BL moves not only at unchanged distance from a wall or floor but also by bounces. It can be explained as follows. We supposed above that time of transient processes is negligible small and there is a steady-state constantly. If there is some latency, for example, the walls or floor are wet and their heating requires some time, an oscillating process can take place. The soliton approaches a wet floor at the distance which is smaller than that for a dry floor because the feedback comes into play with some delay. In this case the air temperature between the soliton and the wet floor is greater and the soliton repels from the floor. The amplitude of soliton oscillations depends on a degree of floor wetness. By the way, the same effect takes place at a soliton penetration through a hole. As is reported in evidence number 100 (Stakhanov, 1997) a ball of 10-15 cm in diameter, passing through a small split in a pane, changed its shape and trembled like a jelly.

Perfectly different situation takes place at approaching the to soliton objects with the great heat conductance (metals, water). In this case the soliton is not able to heat the surface of the object because the heat propagates into the object. As a result, the soliton energy decreases, the soliton becomes instable and explodes. The energy liberated from the soliton at the explosion can damage the objects. There are numerous evidences that BLs cease their existence at touching metallic objects (Stakhanov, 1997, evidence 23, 31, 33, 34, 35, 37, 40, 48, 49, 51, 78).

It is very interesting case where BL touches a face of a thin and long metallic wire which mass is small and the air is heated by the wire in a small degree. In this case the soliton has had a time to heat the wire at the temperature of vaporization. Since the refractive index of metallic vapor at the temperature of vaporization is greater than that of the air at the normal conditions, the soliton does not repel from the hot wire but attracts to it. As a result, the soliton can burn a hole. For example, LB burns a hole of 5 mm in diameter and 3 mm depths in a cleaning rod (Stakhanov 1997, evidences no.4, 34, 35).

The case about which has told K.K.Petrovskiy's to authors is rather indicative in this respect. A Ball Lightning burned out in a cable with a polyethylene shell a copper core at distance of several meters, having left the shell almost untouched. This fact can be explained as follows. Penetrating in

the hole of coating, the soliton acquires a shape of a sausage shown in figure 6. Dependence of the gas density on the distance along the coating hole is shown in figure also. As is seen the gas density decreases with an increase in the distance from face of the wire because the gas pressure decreases. Indeed, the pressure in some region 1 is greater than that in some region 2 located at greater distance from the face than the region 1 because the gas moves from the region 1 to the region 2. The gas refractive index is proportional to the gas pressure all other conditions being the same. Metal within the shell evaporated so quickly that the heat had no time to extend in all sides of the shell. The greatest pressure and, hence, the greatest refractive index is at the end face of the evaporated wire. Therefore during all time of evaporation of wire the soliton in a form of a thin sausage is located within the polyethylene shell.

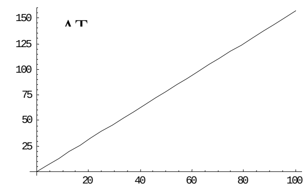


Figure 8. Any point above incline straight line show

Another occasion took place with the Soviet propeller airplane Li-2 which was attacked by BL at the height of 3300 m in partially rained clouds. Immediately after passing a cold thunder front, the airplane was coved by ice. The height of clouds was about 5.5 – 6 Km and the air temperature was about -2 -4^o Celsius. An orange-red fire ball of 25 – 30 cm in diameter approached the airplane in the front. At the distance of 30 – 40 cm from the airplane nose the ball turned to the left and flied past the pilot cabin. At this moment it touched the right propeller and exploded. A single damage which was found out was a damage of a propeller blade. Singer presents a drowning of the damage which is shown in figure 7.

Since a propeller pulls a plane forwards, the excess air pressure takes place near the propeller. The excess pressure is maximal near the end of the propeller blade because the linear speed of this place of the blade is close to maximum. Thus, the pressure is maximal in that part of the propeller blade where damages of the blade edge are seen. Residing in the place of maximal pressure, the soliton rotated with propeller and burned our craters in the same manner as LB burns out craters in motionless metallic things. It does not matter that the linear speed of the propeller region where the damage took place is extremely great. The light speed is greater by one million times. The soliton resides in the space where the air density is maximal independently on either this space is motionless or moves at great speed.

If an obstacle is wet, water vapors appear. Since the refractive index of the water vapors at a normal pressure is equal to n_{water}=1.0002354 and the refractive index of the air at a normal pressure is equal to n_{air}=1.0002727, then the refractive index of appearing gas mixture decreases not only owning increase in the temperature but also owning insertion in the air the gas component with smaller refractive index. Thus, a wet obstruction promotes better repulsion from it.

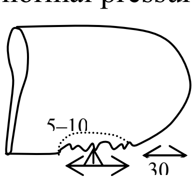


Figure 7. Damages of

Different situation takes place if CO_2 gas is inserted in the air, as it takes place in a burning stove. Since the CO_2 refractive index n_{CO2}=1.0004197 is greater than the air refractive index, the soliton can be drawn in the region where CO_2 percentage is greater. In figure 8 incline straight line divides a majority of points {ΔT, percentage of CO_2} by two parts. The points above the line correspond to the refractive index of the gas mixture that is smaller than that of the air at the normal conditions. The soliton located in the air at the normal conditions is repelled from such gas mixture. On the contrary, the soliton located in the air at the normal conditions is attracted to the gas mixtures corresponding to points below the curve. This example shows that LB can be drawn in a region of space where the temperature is greater.

Thus, a soliton is the most sensible device for determination of the inhomogeneity of the air refractive index or air temperature (if air composition is homogeneous and air pressures in various points of considered space are the same). The soliton moves in a homogeneous air in the direction

opposite to the gradient of the air temperature. Ought to take into account that, approaching some obstruction, the soliton heats it and the air near it and in such a way changes a distribution of the air temperature in space. As a result the soliton can bypass obstructions.

Speed of soliton motion

Let us estimate preliminary the velocity at which a light bubble moves in an inhomogeneous atmosphere. For the sake of simplicity consider an infinite cylindrical layer of compressed air in which an intense light is circulating and supporting the air compression. Let the cylindrical layer of R is located in an inhomogeneous atmosphere which refractive index increases along the x-axis at the rate $g_n = dn/dx > 0$ and does not depend on y, z coordinates (figure 9). If the cylindrical layer is located in a homogeneous atmosphere where $g_n = 0$, then the light makes one revolution around the cylinder axis in time

$$T = 2\pi Rn/c. \tag{1}$$

If the cylindrical layer is located in an inhomogeneous atmosphere where $g_n > 0$, then the light trajectory is not closed. The light shifts additionally at some distance Δx along the x-axis. In accordance with the eikonal equation the additional shift of a light beam in a presence of the additional refractive index gradient g_n is determined by the following expression

$$d^2\Delta x/dt^2 = g_n c^2 \mathrm{Cos}(ct/R) \tag{2}$$

Let the light beam propagates along the arc beginning at point $x=0$, $y=-R$ and ending at point $x=0$, $y=R$. Supposing that at time $t=-(\pi/2)R/c$ the initial speed $d\Delta x/dt$ and initial shift Δx are equal to zero, we obtain from (2) that the total shift of the light beam is

$$\Delta x = (\pi/2) g_n R^2. \tag{3}$$

In this case the speed of shifting is determined by the following expression

$$v = 2\Delta x/T \tag{4}$$

Taking into account (1), we obtain

$$v = g_n Rc/2 = \Delta n_D c/4, \tag{5}$$

where

$$\Delta n_D = g_n D \tag{6}$$

is the change in the atmosphere refractive index at distance equaled to the light bubble diameter. For example, if $\Delta n_D = 10^{-5}$, then $v = 750$ m/s, that is v surpasses the sound speed in air. Ought to underline that a soliton movement is not accompanied by a movement of the air compressed within it. Like light bubble movement through a window glass, where only light radiation penetrates through the glass and compresses new air portion located at the opposite side, light bubble movement in the air atmosphere is accompanied by compression of new air portions along direction of the movement and corresponding release of air portions from the opposite light bubble side.

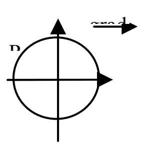


Figure 9.

As is known, the air pressure and therefore the air refractive index gradient change with the height. Because of this the soliton speed change with the height too. Let estimate the soliton speed of falling free. The dependence of the air pressure p on the height h is determined by the following barometric formula

$$p(h) = p_0 \exp(-h/H), \tag{7}$$

where $H = kT/(\mu m_1 g)$, $k = 1.380\ 10^{-23}$ J K^{-1}, μ is the molecular mass of the gas (for the air $\mu=29$), m_1 is the mass of the hydrogen atom and $m_1 = 1.66\ 10^{-27}$ kg, T is the gas temperature (K^0), g=9.8 m/s is the

acceleration of falling free; as is seen p_0 is the pressure at h=0. At T=300 K^0 we have H=8875 m. In this case the dependence of the soliton speed on the height is shown in figure 10.

Certainly, there are temporal changes in a local gradient of the refractive index in space and time, which are essentially greater than the constant change connected with constant decrease in the `shows itself as a lightguide which can guide the light around the earth surface. In this case the gradient of the air refractive index is greater than the curvature of the earth surface $C=1/R=1.57\ 10^{-7}$ m^{-1} where R is the radius of the earth. Then the soliton speed in the region in such gradient is 2.35 m/s. In the same time there are some regions, for example frontal zones, where the air refractive index gradient is significantly greater and the soliton speed can achieve tens meters per second. As follows from the statistics, falling downwards BL are observed approximately in 10 times more often, than rising upwards [2].

How soliton catches flying airplanes

One can conclude that probability of BL appearance near earth surface is greater than that at great height where airplanes are flying. Why BLs prefer to visit flying airplanes (there are many reports) and are perfectly indifferent to airplanes on the earth surface? Where from such yearning for airplane flight? Everybody who looked in an illuminator of a flying airplane may see small clouds and swarms that run away with large speed may ask why BLs are not blown away the airplane wing although very strong wind at speed about 1000 Km per hour blows on the airplane. If BL were composed of some particles, clusters, ions, electron etc., all of these were blown away immediately.

To answer these questions let estimate a degree of atmosphere inhomogeneity produced by a flying airplane. An additional air pressure Δp near a front edge of a wing where the air speed relatively the airplane is maximal and is equal to the airplane speed u relatively the earth is determined by the following expression $\Delta p=\rho u^2/2$, where ρ is the air density and $\rho\cong 1$ kg/m^3. At the airplane speed u=720 Km/h=200m/s we have $\Delta p=2\ 10^4$ Pa≅0.2 atmospheres. The air refractive index at the normal atmosphere pressure is determined by the expression $n=1+\Delta n$, where $\Delta n=2.7\ 10^{-4}$. Then an increase in the air pressure by 0.2 atmosphere entails an increase in the air refractive index by $0.2\Delta n\cong 0.54\ 10^{-4}$. In accordance with (4) to provide a soliton motion at the airplane speed it is necessary the following air inhomogeneity $\Delta n_D=u/(c/4)\cong 2.66\ 10^{-6}$. In this case the soliton may catch up the airplane located from them at distance $S\cong D(\Delta n/\Delta n_D)\cong 20D$ where D is the soliton diameter. At D=0.1 m we obtain S=2 m. Needless to say it is very rough estimations determined the order of magnitude only. But they show that a flying airplane attracts all BLs located directly ahead, as well as to the right, left, at the top and bottom in the region of inhomogeneous atmosphere produced by the airplane. Achieving the airplane, BL stops in the region where the air density is maximal and moves with this region together and, therefore, with the airplane. No airplane maneuvers can separate BL and airplane. Ought to note that the additional air pressure Δp near front edge of the wing is proportional to the square of airplane speed u i. e. the region from which solitons are attracted to the airplane increases with increase in the airplane speed. Besides, the probability for an airplane to meet any BLs is proportional to the airplane speed. Indeed, if the airplane could do several revolutions around the Earth per one second, it could gather all BLs which were met at its trajectory. Are there any other hypothesizes that explain how BLs can pursue an airplane and moves with it together? Such hypothesizes are absent.

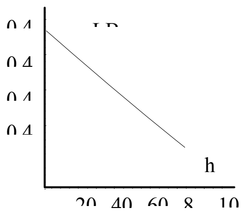


Figure 10.

As is known the air is rarefied at a great height where airplanes fly. Because of this the additional air pressure is generated in an airplane cabin and saloon to provide normal breath for passengers. Since it is very hard and is not justified economically to keep these rooms hermetic

absolutely, there is an air compressor which continuously pumps in the outdoor air. It is natural enough to take the air from that region where the air pressure is maximal that is from the region where BLs are located. The air is pumped by a turbine compressor and there is a tunnel between the salon and outdoor air at any position of turbine blades. The air density gradient is directed into the salon. Moving along the gradient, BL penetrates in the salon. Mechanisms which enable LB to change its shape are considered in [5, 6, 7, 8]. Thus, LBs are specific passengers. They can catch up a flying airplane and come in without any ticket. One can give recommendation to airplane designers to avoid BL penetration. There must be no splits in the region where the additional air pressure is maximal.

The following case which has occurred in the Vologda area in February, 1946 is rather indicative. The second pilot has seen how on the right wing of the plane about green fire there was a bright white sphere. It has thought that there was a short circuit of an electric lamp, but the flash has not disappeared, as usually happens. The sphere has slowly spread on the frontal edge of the wing and has disappeared under the nose part of the machine. Then a loud crash was heard and a black smoke entered in the pilot cabin. Communication has broken. The commander asks the navigator: "Nick, can you have noticed a place the sphere whence was rolled out?" “In fact it has appeared directly near your legs" the navigator has answered: "I have taken the gun for rocket to check up, what color a charge within it. But I had no time to open it. The blinding white sphere has flashed at the very same time. It, as an eye of a devil, peered at me and then has floated to you".

We should note here two circumstances. The sphere moved along a frontal edge of a wing, where pressure of air as much as possible. The sphere has got into a cabin through the hole into which a gun for rocket is inserted. This hole is designated to push rockets outdoor and, therefore, the hole is a tunnel between indoor and outdoor spaces. The air pressure in a cabin of the plane is greater than that outdoor, because air is rarefied at the great height where planes fly. In the same time the air pressure in the cabin of the plane for comfort of pilots is supported to the pressure close to normal one. Therefore the sphere, moving in the direction of the gradient of the air density, has got into the cabin through the hole in which the gun for rocket was inserted.

At description of collisions of planes with BL damaged or melted off rivets in a forward part of a fuselage are mentioned [9]. It is easy to explain because the rivet edged on a smooth surface of a fuselage breaks a uniform air flow near the fuselage. The excess pressure is created near the rivet, and there is a local maximum of the air density. Having got in this maximum, LB evaporates a part of the rivet. This action is explained by the same mechanisms which are responsible for evaporation of long metal cylinders. Evaporation occurs until the edged part of the rivet disappears that leads to a disappearance of the excess pressure created by edged part of the rivet.

In our opinion, an explanation of mechanisms which enable BL to catch up and accompany airplanes is a strong argument in favor of an optical nature of Ball Lightning. No particles can accompany an airplane. They will be blown out by a stream of running air immediately. On the contrary, it does not matter for light circulating in the space where air pressure is maximal whether motionless or moving air produces the excess pressure, because the speed of moving air is smaller by million times than light speed is.

Soliton behavior near metallic objects

Now consider the question why BL is not indifferent to metallic things. There are many reports that BLs are attracted to metallic objects such as wire fences or telephone lines. When attached to metallic objects BLs generally move along those objects. The point is that all metallic objects offer not only good electric conduction but also good heat conduction. Because of 24-hourly temperature changes the temperature of various objects at the earth surface is not identical. In sun

day the temperature of upper layer of earth surface is greater than that of layers located more deeply. For example, if a metallic pole is droved in earth, the pole temperature is smaller than that of surrounding air because the heat which the pole obtains from the air propagates downward in the bottom end of the pole. As a result, in the region near the pole the air density gradient is directed to the pole surface. Appearing in the region, a soliton begins to near the pole. If the air refractive index gradient is not perpendicular to the pole axis then the soliton, approaching pole and heating the air layer between the soliton and pole, begin a motion along the pole axis at some distance from the pole surface. In general, the soliton obeys the first Newton law of uniform movement. Indeed, if the soliton moves in some direction in a homogeneous air, the soliton leaves behind it the air which is warmer than that fore of it. This is favorable to further movement.

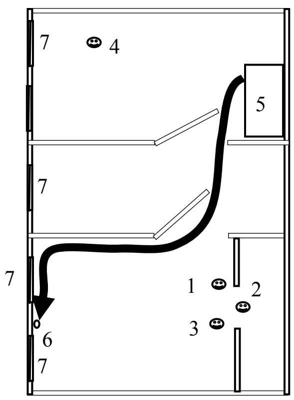


Figure 11. Trajectory of

For example evidence number 8 is described , in [3] where two Ball Lightnings appear from stove 5 (figure 11), pass through 2 doors, and along walls approach grounding 6 in a form of a metal wire. A trajectory of Ball Lightnings is shown in figure 11. The BL motion is observed by 4 witnesses 1, 2, 3, 4. Approaching the wire between windows 7, BLs change their shape in an elongate ellipsoid, penetrate though a split between the wire and floor, and disappear.

Penetrating through chimney in stove 5, solitons move in the direction where the air is cooler. Since the wire of grounding is barred deeply in the ground where the temperature is smaller than that in the room, the wire is cooler than the air surrounding it. The wire produces near itself the refractive index gradient directed downwards.

It is known with assurance that BLs can damage wiring, burn fuses, screw plug fuses etc. One can ask if BL is not connected with the electricity perfectly, what is responsible for these phenomena. A credible speculation is proposed by Stakhanov [3] who supposes that events occur in the electrify space where the strength of the electrical field is about 3 – 30 kV/cm. An explosion of BL entails redistribution of the electrical parameters of the space, in particular, the electrical field and voltage in the large enough volume. Such redistributions can be sensed by peoples as an electrical shock. Besides, as is known the voltage of an electrical conductor is constant at a steady-state and there are no currents within the conductor. A redistribution of the electrical field forces a redistribution of electrical charges at the conductor surface that is the current in the conductor. This current can be a reason of the above-mentioned troubles.

In some cases interaction LB with metal subjects gets other character. It occurs when the geometry of a metal object is those that LB can adjoin only to its small part. For example, BL adjoins to an end face of a metal wire. In this case conditions of distribution of heat in metal differ from the case when LB can adjoin with the metal body which sizes in all three dimensions are comparable .In the first case heat can propagate only in one measurement - along a wire. In the second case heat can extend in three measurements. Therefore in the first case heating of metal in the place where LB is located is much greater than in the second one.

If the temperature of metal raises so that evaporation begins, situation changes radically. The refractive index in the space where evaporation takes place increases due to increasing the refractive index because an insertion of new portions of matter in this space. Since a soliton tends to the space where the refractive index is maximal, the soliton locates near the place. The soliton evaporates the wire until either its energy exhausts or the wire evaporates completely.

The presented picture has numerous confirmations of eyewitnesses. The witness saw, how after an extremely strong strike of a lightning in a telephone column a bright ball of 1 m diameter

rolls along a street and after it some more spheres of smaller diameter [10]. It was revealed later that the wire between two columns is torn off and its significant piece disappeared.

In other case a very strong stroke of a lightning has destroyed a copper antenna after it has been established for studying a storm electricity.

The witness observed a thunder-storm has noticed the big fiery sphere, apparently, formed owing to vaporization of 65 m wire of 2mm in diameter.

Stakhanov in case of number 4 describes a case, when BL burned out space of 5 mm diameter and 3 mm depth at an end face of a ramrod attached to a gun. It is marked, that there were no traces of welding. Metal has simply disappeared.

Large soliton and Flying spice are the same

It is very interesting which shape takes a large soliton of several meters diameter. In accordance with our approach any soliton tends to the space where the refractive index is maximal. What is happened if the refractive index changes along height in such a way that its changes are distinctly at the distance equaled to the soliton diameter? In this case the soliton equator is located in the layer where the air density is maximal as is shown in figure 12. The top and bottom poles are located in layers where the air refractive indexes are smaller. In this case the air density gradient in the layers is directed to the equator. As a result, there are forces above equator that tend to near the soliton top surface to the equator and there are forces below equator that tend to come close bottom surface to the equator. In other words, there are forces which tend to flatten the soliton.

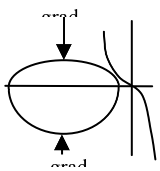


Figure 12. Form of BL of great diameter in a

It was shown that inner forces that provide a spherical shape of soliton is small enough in such a degree that the soliton changes its form in inhomogeneous air space. In particular, BL takes a shape of a sausage to penetrate in a room through a hole which diameter is smaller than soliton one. The forces which provide spherical shape of the soliton are in inverse proportion to the square of the soliton diameter. In this case the forces which tend to flatten the soliton increases with increase in its diameter but the forces which provide spherical shape for the soliton decrease. As a result, a change of the soliton shape may be noticeable and the soliton is transformed from a sphere into an ellipsoid of revolution.

If the air density gradient distributions are not identical at the top and bottom poles (typical case), the deformations of the soliton shape are not identical also and the soliton is shaped into a body of revolution reminding a spice or plate.

Among many known various fantastic properties of flying spices there is decisive evidence that they can move with the large speed and change a direction of speed so sharply, that overloads arising at it are inadmissible for living beings. If flying spices are soliton in fact, they can move at the large speed provided that the refractive index gradient in the air atmosphere is great enough. In the event that an atmosphere non-stationary, there can be areas in which the direction of the air density gradient changes sharply enough. In such areas solitons sharply change the direction of motion. In accordance with (6) the soliton speed is proportional to the soliton diameter. Therefore there is nothing surprising that the great soliton can move at large speed.

Why directions of wind and soliton motion can be different

One more solution of abnormal properties BL is connected with an explanation why the direction of BL movement can be different from a direction of a wind. The explanation of this BL feature, alongside with an explanation of the mechanism of penetration BL through glass and the

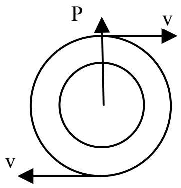


Figure 13.

mechanisms allowing BL to catch up and accompany planes, is the third powerful argument in favor of optical BL nature.

Explanation is simple enough. A soliton moves along the refractive index gradient which direction can be different from a direction of the air speed. This explanation is complete however it is meaningful to give some additional arguments. In figure 13 a particular case of a vertex motion of air is presented. In this case the air velocity is directed along a tangent to a circle. As to the air pressure, it is identical on this circle owning to an axial symmetry of the system. Then the tangential component of the pressure gradient is equal to zero and the gradient is directed along radiuses. At approach the center the air pressure decreases. It provides occurrence of centripetal forces providing movement of air with centripetal acceleration, directed to the center of the circle. As the air refractive index is proportional to air pressure with other things being equal the air refractive index gradient is proportional to the air pressure gradient. Thus, the refractive index gradient is perpendicular to the air speed and the soliton in this case moves perpendicularly to the wind.

By the way, if an air moves in some pipe or in some crack, the direction of the air pressure gradient is opposite to the air velocity. In this case, unlike movement of all known objects along the air velocity, the soliton moves in a pine against the air speed. Indeed, the air moves from the space with the high pressure to the space with the lower pressure. On the contrary, the soliton moves from the space with the low pressure to the space with the high pressure.

Why soliton seems cold

One more additional argument in favor of optical BL nature is an explanation of the following seeming contradiction. The majority of physicists if not everybody are perplexed why BL radiates white light which spectrum corresponds to the temperature of the body heated at some thousand degrees, and at the same time BL rather cold as it does not burn objects being about it. There is a simple explanation of this paradox. The light which radiates BL is not produced by exited atoms as it takes place at radiation of light by any heated body. The light radiated by LB is the light which appears as a result of scattering of intensive light, circulating in LB shell. Really, white light has been produced by excited atoms of air at the moment of gas discharge at a strike of conventional linear lightning when LB was generated. This light has been caught in a light bubble and was circulating within rather long time. LB can already be far from a place of its appearance and air by this time can already cool down. Thus, the nature of the light radiated by LB differs from the light radiated by the heated body. LB has caught and has preserved the light radiation which has arisen at a strike of a usual linear lightning, and gradually radiates it in a form of scattering light. The intensity of the scattering light is small and because of this the light is cold.

Why soliton hisses and causes radio interferences

Being at a steady-state, the soliton shape is unchanged and there is no noise form the soliton. Considering the soliton as an elastic shell, we need to recognize that there is a majority of eigen frequencies for mechanical oscillations of the shell. These oscillations may be excited by various inhomogeneities which the soliton meets at its way, in particular, particles of dust. If the eigen frequencies are distributed along sound spectrum uniformly, a hissing sound may be heard. A similar sound may be heard in a radio dynamic if the gain of an amplifier is greater than nominal one.

As far as radio interferences is concerned, that an influence of BL on a radio receiver is mentioned by many eyewitnesses [11]. But it does not mean that LB generates radio waves as many scientists believe. Cracks from LB were heard in a telephone tube too [3] which as is known is not

capable to receive radio waves. The following explanation may be proposed. LB can have electrical charges. Having oscillated in its form at sound frequencies, LB causes a redistribution of the voltage in space surrounding it. Such redistribution is responsible also for electrical effects at LB explosion. The same effect causes cracks in a radio receiver and telephone tube. One can recall cracks in a radio receiver when electrical lamps are turned on or turned off.

Why the soliton may be variously colored

There are many reports in which BL colors are various. Along with this there are many various explanations of these observations. For example Turner [1] believed that much of variability in the color of ball lightning results from traces of contaminants. These can presumably be present as a result of the formation of a ball around a solid nucleus or contaminants with dust. Certainly, greenish balls have been seen to detach themselves from what one would expect to have been copper wires. He attributed the blue halos observed around some (presumably clean) balls to common charge neutralization reaction which just happens to be endothermic on some occasions. He also suggested that the very common red or yellow color might result from organic contaminants.

We give our own explanation why LB color can be various beginning from reddish and ending bluish whereas the color of usual linear lightning is white. Most simply to answer this question it would be possible so. The temperature of area in which LB appearance takes place can be the most various depending on conditions of gas discharge. As is known, the maximum of a spectrum moves in a short-wave part of a spectrum at an increase in the temperature. As LB represents a combination of the compressed gas and intensive electromagnetic radiation, and the maximum of a spectrum of electromagnetic radiation can change over a wide range also, LB color, which is defined by a maximum of this spectrum, can be too over a wide range. On this simple explanation various subtleties can be imposed. For example, LB appears as a result of numerous merges of tiny LBs of small diameter which radiating losses depend on wavelength of the light circulating in them. Most quickly such LB loses the radiation in a long-wave part of a spectrum. As a result, the average wavelength of the spectrum moves in a short-wave part. In this case LB, formed because of merge numerous tiny LBs, has a violet shade. Such LBs were observed in experiments [10].

Soliton disappearance

As for process of a soliton disappearance it is fast enough. The soliton disappears when it becomes instable because of continuous radiation losses (although a soliton stability is conventional because there is no steady-state due to continuous radiation losses). As processes with participation of light have rather small time constants, transient processes in the soliton are very quickly. The air pressure gradually decreases with gradual decreasing the light intensity. This entails increasing radiation losses and, therefore, further decreasing the light intensity and so on. In the long run the light ceases to be held by the compressed air and is radiated in all sides. The compressed air is no longer held by the light and begins to expand. Time constant of this process is determined by the sound speed in air which is smaller by six orders of magnitude than that of light. A small popping or great explosion may be heard. Often is reported that a sound of the explosions reminding a pistol shoot is heard. This testifies that amount of the compressed air is relatively small and the air compression is great enough.

If the soliton disappears silently it testifies that the soliton shell consists of moderately compressed gases which refractive index is greater than that of air rather than of strongly compressed air.

Protection against Ball Lights

Taking into account the above consideration, we can draw certain recommendations how avoid damages from the BL. The most radical way is to decrease the air density in the room. In this case the outdoor air is drawn in the room but the LBs, contrary to expectations, are pushed off the room. An increase in the room temperature results the same effect. If the LB is appears to be in a room that it is not recommended to wave by hands or, for example, to drive it away by a besom because a region with the excess air pressure is generated between the LB and besom. The LB will approaches to the besom. It is not recommended to blow at the LB because the LB will near the region with the excess pressure. This region is a source of the wind. One can move a plane non-transparent object closer to the LB, for example, a great book with a dark cover. After heating the air layer between the LB and book, the book will push off the LB. We propose to readers to explain behavior of BL if a bullet is shot in it. In our turn we will try to prove that BL was a possible reason of Chernobyl tragedy.

Analysis of the reasons of this tragedy has been carried out by many researchers. The official version declares that the tragedy grows from mistakes of the personnel aggravated by a fatal coincidence of circumstances and some constructional lacks of a reactor. Undoubtedly, such mistakes of the personnel and constructional lacks took place. But was it the genius reason of the tragedy? It is impossible to prove or disprove it. There is a simple example. There was a road and a transport incident on highway at which a car has appeared in a ditch. Investigating the reasons of the incident, a car inspection has established that the driver has considerably exceeded the speed, and its car was technically out of order: bad brakes, inadmissible defects in a steering management etc. All of this could lead to the incident. However more careful research have shown that directly ahead of the incident a truck came to close the car on a counter strip, and the driver need to move to a ditch to avoid collision. There is a question. Possibly, were there any unknown reasons similar to a truck moving on a counter strip? It has appeared that such reason could be. Harmless at first sight electro technical tests of the electro generator which begun just one minute prior to the tragedy. As a result of these tests BL could appear which penetrated in the nuclear reactor zone and bring it out of order.

It is well-known, that especially often Ball Lightnings arise in accumulator submarines at switching electro motors. Such Ball Lightnings fly on cabins and sometimes burn racks and burn partitions. Numerous certificates of occurrence of fiery spheres are described in the monograph of Barry [12], devoted to Ball Lightnings. For example, Nilson, Norwegian expert in hydro energetic, has shown that reddish shone matter was separated and remained visible in air within several seconds at a short close of a direct current generator. A photo of the shone sphere which has separated from the shone matter is presented in the book. There are evidence that a Ball Lightning about 20 cm in diameter burned out a hole of 7 cm diameter in a lateral wall of a factory pipe ([3], a case 34), and also numerous evidence haw Ball Lightnings appearing in interiors of planes burn their covering. Holes of the correct round form burned out in metal targets (aluminum, titan, tungsten) can be seen in the photos in figure 22 in book [14].

The eyewitness of tragedy physicist Urutskoev asserts that a burned out hole of regular circle form was in the wall of the mine of the nuclear reactor. Various substances which are prone to erosion at the gas discharge can be used. For example, in experiments on production of artificial Ball Lightnings the wax preliminary put on electrodes between which took place the discharge was used [10]. Metals, various polymers, cotton wool, shavings of a tree were used in other experiments [15]. Apparently, the transformer oil manifested itself as such substance at production of the Ball Lightning in the machine hall. According to the chief of the team produced the test there was a fire at bottom floor and transformer oil was burned [16]. After appearance a Ball Lightning at erosive gas discharge, events could occur as follows. The Ball Lightning has got through a burned hole into

a steam line and, moving along the refractive index gradient, has got in a place where water is converted into a vapor and, hence, "erosion" of water takes place. Density the pair and, hence, the refractive index in this place are maximal. Having reached this area and having destroyed heat producing element the Ball Lightning has got in mine. After then BLs was drew to a metal leaf of the mine, in which it burned out a hole of the regular circle form. After disappearance of the Ball Lightning vapors of transformer oil compressed in the BL shell have remained. They have extended and gradually condensed on walls of the mine. As Urutskoev noted, walls of the mine have been covered by an oil emulsion.

Conclusion

Believing a priori, that light bubbles are an objective reality, we have shown that in accordance with well-known laws of physics behaviour of light bubbles in the conventional air atmosphere is completely identical to a mysterious and paradoxical behaviour of Ball Lightnings. Too many riddles connected with of Ball Lightnings can be explained under an assumption, that BLs are light bubbles.

It is generally accepted that BL has properties which combination is absent in any known object. Indeed one can imagine the object which moves against wind. This is a bird. One can imagine the object which penetrated through window panes. This is the light. One can imagine the object which radiated the light. It is a firefly. One can imagine the object which can catch up a flying airplane. This is other airplane. But it is impossible to imagine the object which has all these properties simultaneously. It must be something radically new because all attempts in many centuries to explain BL nature on the basis of known knowledge were finished by the failure. None of 200 existing now BL theories can explain a combination of BL properties. A perfectly new unknown up to now object which has all BL properties is required. We have shown in this section that our light bubble has simultaneously all listed properties. It is improbable that it is a simple fortuitous accident.

From the presented consideration it is necessary to draw a conclusion, that light bubbles are not game of mind, but it is an objective reality. Till now light bubbles were studied neither theoretically, nor experimentally. Anybody did not suspect at all about an opportunity of their existence. At this point it would be possible to finish activity on an explanation of the nature of Ball Lightnings and to expect a general recognition of the presented hypothesis.

Unfortunately, new theories win a general recognition not so promptly as we would like. For example, about a century was required for Copernicus theory that the earth rotates around the sun to win a general recognition. Having no opportunity to wait for so much time, we undertook further steps in search of new additional arguments in favor of light bubble existence. Properties of objects for which has been absent yet a generally recognized name and which are produced in laboratories by scientists in last two centuries at attempts to produce artificial BLs have been analyzed and investigated. This activity resulted not only additional evidences in validity of accepted approach but also disclosing new physical effects deduces from analysis of experimental data obtained on investigation of the objects. These problems are considered in the next chapter.

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Space Spherical Solitons and Natural Radioactive Decay

Abstract

An attempt to extrapolate a notion of light bubble for nuclear processes is undertaken. Indeed, there is a natural radioactive decay at which nuclei decays abruptly in the same way as light bubbles do. An existence of light bubbles is explained by wave phenomena. In accordance with quantum mechanics an existence of nuclear objects is explained by wave phenomenon too. From similarity of nuclei and light bubbles follows that because of inevitable radiation losses inherent to waves of whispering gallery type the energy stored in a nucleus should gradually increase in time. It turns out that this does not contradict to the generally accepted fact that the nucleus energy in unchanged in time. It is shown that gradual decreasing of total energy of a system consisting of many identical nuclei manifests itself in abrupt decrease of number nuclei in the system. Since nuclei with smallest energy disappear from the system, the average energy of remained nuclei is constant in time. Features of interaction of a system of nonlinear identical oscillators are considered. Extrapolation of obtained results on a system of identical nuclei enabled to conclude that quickly prepared long-living gas of densely packed molecules if favorable for an increase of the speed of radioactive decay. Numerous experiments confirmed this conclusion are considered.

As is known, introduction into consideration oscillators has allowed Planck, Einstein, Debye and other physicists to develop an absolutely new approach to an explanation of many physical phenomena. As a classical oscillator was imagined as a mechanical oscillatory system, the further research in this direction have led to the appearance of quantum mechanics although it deals with waves in a form of wave functions. Studying of BL nature has allowed to introduce into consideration other types of oscillators, in particular, to study oscillators where whispering gallery light waves take part. Life time of such wave is finite because of inevitable radiating losses inherited to waves of such type. The further comparison between the oscillators and BL has led to consideration of the self-confined waves of whispering gallery type. In modern terms such formations are optical spherical spatial solitons (OSSS). OSSS represents the resonator for a wave of whispering gallery type formed by this wave in a nonlinear optical medium. Unlike usual optical resonators for waves of whispering gallery type [1] in which the light wave of any amplitude can circulate, OSSS can exist only provided that the amplitude of a circulating wave surpasses some threshold. When because of inevitable radiating losses the amplitude falls below this threshold, OSSS becomes instable and disappears in the same way, as BL does.

The same occurs to nuclei of chemical elements. They sharply cease their existence with breaking up and forming other nuclei. This phenomenon has been discovered in the beginning of 20 century and is called as natural radioactive decay. Since this phenomenon reminds existence and disappearance of BL, it is interesting to investigate this similarity in more details. It is especially interesting, as BL and a nucleus are presented by waves. Similarity in the nature of tunnels for light waves in optics and for wave functions in quantum mechanics is so great, that optical analogies are often used for an explanation of tunnel effects in nuclear physics [2]. By the way, a wave function of a nucleus can be a whispering gallery type too. Certainly, this wave function also satisfies to a wave equation. In this case similarity becomes full, and all the conclusions obtained for self-confined waveguides for waves of whispering gallery type [3, 4, 5] which are a basis of BL theory, can be applied to wave functions too.

A hierarchy of various forms of spherical space solitons is presented in figure 14. Till now we considered the left part of figure where IOSSS is an abstract notion or theoretical model and

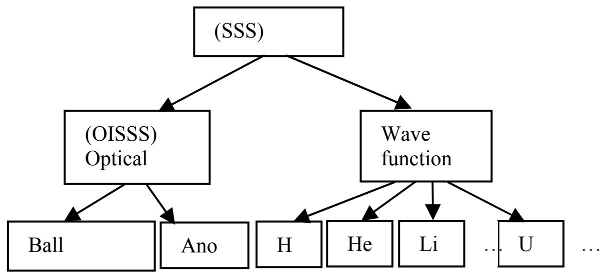

Figure 14 Hierarchy of various forms of spherical space soliton and their

BL or AO are its real representatives in the nature. The right part presents a particular case of SSS where a self-confined whispering gallery waves are wave function type. Nuclei of various chemical elements are its real representatives in the nature. It is interesting to consider consequences of such assumption. Like IOSSS where the intensity of light waves of whispering gallery type gradually decreases in time because of inevitable radiating losses inherent to whispering gallery waves, we need to accept that wave function of SSS decreases gradually in time too. Moreover, we should accept that the square of the module of a wave function characterizes the density of energy, rather than the density of probability as it is usually considered.

Seemingly, these assumptions contradict to the experimental facts according to which energy of any nucleus is constant in time. Besides, as follows from these assumptions, all nuclei should be stable during all their life, and then they should break up simultaneously when their energy becomes below a certain threshold. It has appeared that these fears are deprived bases. Really, considering nuclei as specific spherical spatial soliton, we should agree that nuclei interact one with another and they exchange by their energy. From here follows, that energies of nuclei are distributed in some narrow interval. When energy of some nucleus becomes below a certain threshold, it breaks up and disappears from the set of identical interacting nuclei. Disappearance of the nucleus which energy is smaller than average energy in the set entails an increase in average energy of the remained nuclei. This shift of average energy is compensated by a gradual continuous and monotonous reduction of energy in time of all remained nuclei because of radiating losses. As a result, average energy of nuclei remains constant. External characteristics of radioactive decay completely coincide with experimentally observable ones.

This conclusion is valid in the case where a system of nuclei is in a steady-state. If somehow the steady state is violated, at this time the speed of the radioactive decay can be changed.

Interaction of a set of identical oscillators in a form of the self-confined wave function

Such oscillators are characterized by a feature that the energy stored in an oscillator decreases gradually in time because of radiating losses. As a result, all oscillators are in the common field produced by them. As is known, radiating losses of an optical oscillator in which light wave of whispering gallery type is circulating are defined by parameter $N = 2\pi r_0/\lambda$, where r_0 is radius of sphere, λ is wavelength of light wave. As shown in [6], the quality index determined by radiating losses for a glass ball with $N = 2000$, is equal $Q = 10^{400}$. Energy of oscillations in the resonator decreases as follows

$$E = E_0\exp(-2\omega t/Q) = E_0\exp(-\gamma t), \qquad (8)$$

where $\gamma = 2\omega/Q$. Assuming, that for a light wave $\omega = 10^{15}$ c^{-1} and lifetime of a of light is defined only radiating losses, we obtain unimaginably large value equaled to 10^{378} years.

Consider now interaction between a set of chaotically moving identical nonlinear oscillators in which the stored energy gradually decreases in time. Similarly to molecules of gas in a closed vessel, oscillators can casually collide one with other. Thus everyone oscillator can either acquire or loose any energy at collision. Finally, a normal distribution of energies of oscillators comes (figure 15) at which a probability p of an oscillator to have energy in a range from E to $E + \delta E$ is equal to $p(E)\delta E$, where

$$p(E) = \sigma^{-1}\pi^{-1/2}\exp[-(E - E_0)^2/\sigma^2], \tag{9}$$

$\sigma = F(k)$, $F(k)$ is some increasing function.

As follows from (9), $p(E_{\text{th}}) > 0$, where E_{th} is the threshold at which oscillator should disappear. Since a number of nonlinear oscillators in the system decreases, the distribution (9) is pseudo steady-state. Disappearance of an oscillator with minimal energy E_{th} is accompanied by an increase in average energy of remaining oscillators $<E>$ by $(E_0 - E_{\text{th}})/N$, where $N >> 1$ is the number of oscillators in the system. Indeed, the average energy of oscillators can be presented as follows:

$$\langle E\rangle = N^{-1}\sum_{i=1}^{N} E_i = N^{-1}\sum_{i=1}^{N}(E_0 + \Delta E_i) = E_0 + N^{-1}\sum_{i=1}^{N}\Delta E_i \tag{10}$$

where E_{i} is the energy of i-th oscillator, $\Delta E_{\text{i}} = E_{\text{i}} - E_0$ and $\sum_{i=1}^{N}\Delta E_i = 0$

Assume that an oscillator with number N disappears. In this case its energy is equal to E_{th}, and the term in (10) for which $\Delta E_{\text{N}} = E_{\text{th}} - E_0 < 0$ disappears too.

Then $\sum_{i=1}^{N-1}\Delta E_i = (E_0 - E_{th}) > 0$

and

$$\langle E\rangle = E_0 + (E_0 - E_{th})(N-1)^{-1}. \tag{11}$$

If the number of disappearance per second is λN, then the total energy increases by $\lambda(E_0 - E_{\text{th}})$. This increase is compensated by a decrease in total energy because of inevitable radiating losses in each oscillator in accordance with (8). Then

$$\mathrm{d}E/\mathrm{d}t = -\gamma E(t). \tag{12}$$

The decrease in accompanied by exchanges of portions of energy at collisions of oscillators. Such exchange promotes that distribution of energy between oscillators tends to normal one. This tendency is violated by disappearance oscillators, which energy is smaller than threshold E_{th}. Thus, the gradual decrease in energy in everyone oscillator is transformed to sequence discrete decreases of the system energy due to disappearance oscillators. Speed of the constant decrease in the total energy is defined (12) and is agreed with the speed of decreasing number of oscillators that is determined as follows

$$\mathrm{d}N/\mathrm{d}t = -\lambda N(t), \tag{13}$$

where N is total number of oscillators in the system, λ is a probability of disappearance of oscillators per one second. Since the total energy in the system is proportional to the number oscillators in it, then $\mathrm{d}N/N = \mathrm{d}E/E$, and from (12), (13) we have

$$\lambda = \gamma. \tag{14}$$

Note that this relation depends on neither internal parameters of oscillators, nor on the parameters describing their collisions, such as strength of interaction characterized by dimensionless coupling index k, duration of collision τ_R, frequency of collisions. This conclusion is valid for any system in steady state when average speed of gradual increase in the total energy is equal to average speed of increase because of disappearances of oscillators. Let show that this steady state is stable. Let the curve 1 in figure 15 represents normal distribution of the density of probability for oscillator to have energy E. The area under this curve is equal 1. The curve has a maximum at $E = E_0$, and its width depends on the coupling index between oscillators at their collision. If energy of the some oscillator becomes equal E_{th}, oscillator disappears. The smaller difference between E_0 and E_{th}, the greater is probability of its disappearance.

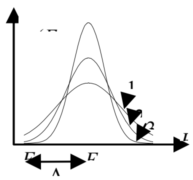

Figure 15. Dependence of density of

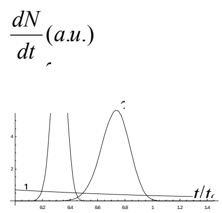

Figure 16. Dependence of radioactive decay on time. 1 – natural

Suppose that maximum of curve 1 takes place at $E = E_1$ where $E_1 < E_0$, that is the curve 1 is shifted to the left. In this case, as follows from figure 15, the speed of disappearance of oscillators raises as compared with the speed at steady state when $E = E_0$. As has been shown, a disappearance of each oscillator is accompanied by an increase in average energy remained oscillators by $\Delta E/N$, where $\Delta E = E_1 - E_{th}$. The greater the speed of disappearances is the greater speed of an increase in average energy. As a result, E_1 increases. This leads to shift of curve 1 to the right, and the speed of disappearance oscillators with energy E_{th} decreases. Such process proceeds until a steady state will be achieved and condition (14) becomes valid. The case when $E_1 > E_0$ can be considered similarly.

Ought to note this conclusion is valid for any form of curve 1. For example, the same reasoning could be applied for curves 2 and 3. It means that the conclusion about validity of condition (14) does not depend on the coupling index. Notice, that number of oscillators which disappear when their energy becomes equal E_{th}, does not depend not only on probability $p(E_{th})$, but also on frequency of collisions. Probability $p(E_0)$ in comparable with $p(E_{th})$ in figure 15 for the sake of illustrative reasons only. Actually $p(E_0)$ is greater than $p(E_{th})$ by many orders of magnitude.

Under assumption that energy of an isolated oscillator is unchanged in time we receive $\gamma = 0$, and, therefore, from (14) $\lambda = 0$. In this case speed of disappearance of oscillators decreases in time and tends to zero at approach to steady state. This contradicts to experimental data.

Notice that the presented considerations are not valid for transient processes in the system. Consider several examples for the sake of illustration. Assume, that the coupling index becomes equal to zero at $t = 0$. In this case interaction between oscillators ceases and their energies tend to E_{th} independently. The total energy of the system gradually decreases and maximum of curve 1 in fig. 15 moves in a direction to E_{th}. In this case the probability of disappearance of oscillators raises with time. Energy oscillators which will disappear at time instant t, is equal $E = E_{th}\exp(\gamma t)$. Taking into account (9), the probability of disappearance of oscillators can be presented as follows:

$$p(t) \sim \exp\{-\frac{[E_{th}\exp(\gamma t) - E_0]^2}{\sigma^2}\}$$

Curve 1 in figure 16 shows dependence dN/dt on t in steady state when $\gamma = \lambda$, curve 2 shows the same dependence when the coupling index becomes equal to zero at $t = 0$. It is supposed, that $\sigma/E_{th} = 0.05$ and $E_{th}/E_0 = 0.8$. As is seen from figure 16, at $t = 0$, dN/dt for curve 2 is much smaller, than that for curve 1. However at $t \approx 0.3t_{0.5}$ dN/dt for curve 2 surpasses dN/dt for curve 1 approximately by 30 times, where $t_{0,5}$ is the time period in which number of oscillators decreases by two times. Dependence dN/dt on t at $\sigma/E_{th} = 0.1$ and $E_{th}/E_0 = 0.6$ is presented by curve 3 in figure 16. In this case maximum of disappearance of oscillators comes later at $t \approx 0.75\ t_{0.5}$.

Thus, if the curves similar to dependences 2 and 3 could be obtained experimentally, σ and E_{th}/E_0 could be calculated, and average value of coupling index k could be estimated.

The experimental data about a change of speed of radioactive decay with a change of external conditions

According to existing representations "λ is one of the major characteristics of atom nucleus: λ does not depend on physical and chemical conditions, such as temperature, pressure, concentration, a chemical compound, from age of a radioactive nucleus" [7]. In our designations it concerns to a constant γ, which is determined by internal properties of a nucleus and can not be changed by external forces. In the encyclopedia it concerns to a constant λ which can be determined experimentally. According to (14) $\lambda = \gamma$ at any steady state. However these constants can differ during transient processes.

There are enough both old and new works as theoretical so experimental character that point out at an opportunity of changing radioactive decay speed. For example, recently it has been shown, that the greatest stability in isobar series, i.e. among elements with identical nuclear weight, has an atom with minimal energy. Not only very energy of nucleus is taken into account but also the addition in a form of energy of electron environment of the nucleus. This energy is equal to 13.6 eV for hydrogen atom and to several thousand eVs for atoms with $Z > 20$, where Z is number of protons in an atom. This addition is smaller by 3-4 orders of magnitude than the energy of a nucleus equal approximately 931.5*A MeV, where A is atom weight of a nucleus.

Modern accuracy of measurement of atom weights is equal about 1 000 eV. Thus, now energy of atom can be measured in view of energy of an electronic environment. The analysis of accessible experimental data [8] has shown that a stable atom takes place only at a minimum of its energy. Such conditions as "the minimum of weight of a nucleus" or "a maximum of energy of connection" appear insolvent [9].

This conclusion can be explained in a natural way on the basis of presented approach. Really, a continuous slow decrease in the energy stored in an atom leads to passage of the in new steady state with smaller energy. Such condition is available for all atoms in isobar series, except for atom with minimal energy. For this atom decrease in the energy should be immeasurably greater that it could pass in the steady state related with another isobar series. Time required for a decrease in the energy in this case should be immeasurably greater. Differently, time of half-decay of such atom should be immeasurably greater, that is it should be practically stable.

There are several important consequences from presented consideration. First, an atom and its electronic environment represent a single whole entity, and it is necessary to consider their general energy. Secondly, difference $E_0 - E_{th}$ is rather small as compared with E_0. In the third, full ionization of atom reduces this difference considerably, as energy of ionization is comparable with the difference between energies of atoms in common isobar series. As the consequence, full ionization of atom should change its half-life period noticeably. Experiments [10], [Bosch, 1996] confirm this conclusion. It is shown, that the half-life period completely ionized atom ^{187}Re decreases by in 10^9 times as compared with a neutral atom (the half-life period decreases from 4,3 10^{10} years to 33 years).

Influence of an electric field of atom on probability of beta decay is considered in details in surveys [11], [12] where experimental data are presented also. Influence of changes of an electronic environment of atom on beta decay of a nucleus tritium is considered in detail in works [13], [14] where convincing experimental data are presented also.

It is shown [15] that radiation of uranium after electrolysis increased by 2 times as compared with initial material U_3O_8. As concentration of uranium after electrolysis has appeared at 30 %

above, than in the initial material, the normalized emission of α-particles in uranium after electrolysis became at 30 % greater than in a initial material.

The presented approach, at which the nucleus is considered as spherical self-confined soliton in which the stored energy constantly decreases because of radiating losses, enables to connect a natural radio-activity with gradual decreasing energy of a nucleus. Randomness of natural radioactive decay can be explained not some unknown processes within a nucleus but random processes outside a nucleus provided the stored energy in a nucleus gradually decreases. If to accept, that energy of a nucleus is constant, speed of radioactive decay should gradually decrease at the accepted approach. That fact that external conditions can influence at a speed of radioactive decay confirms the right on existence of the presented approach.

Theoretical preconditions for increasing speed of natural radioactive decay

A natural question arises. Whether a speed of radioactive decay can be changed in such a degree that energy that is exerted at any nuclear conversion can be used in alternative sources of energy? As has been shown above, the inner energy within a nucleus decreases gradually in time as well as changes abruptly at collision of nuclei. When the inner energy decreases down to the threshold at which the nucleus becomes instable, the nucleus breaks up and some excess energy liberates from the nuclei. Unfortunately the intensity of this process is extremely small for all of natural chemical elements. By the way, such process is used in Plutonium power suppliers located on satellites. Their power is about 3 kW and duration of operating is about 80 years. But they are very expensive devices because very expensive substance is used as a fuel. Usual natural matter widely spread in nature is desirable to use as a fuel.

The simplest way to increase the speed of a radioactive decay is to increase coupling index k which characterizes strength of interaction. It turns out that it is insufficient. Unlike molecules of gas which are considered as elastic balls at their interaction at collisions and their energy is proportional to the square of their velocity, interaction of oscillators is perfectly different. Firstly, the energy of oscillator is not connected with its velocity. In this case motionless adjacent oscillators can interact one with another and duration of their interaction can be as great as is wished. Secondly, an oscillator is excellent accumulator of energy if the speed of transmission of energy into the oscillator is greater essentially than the speed of a decrease of energy due to radiating loses. Reality shows that this condition is held with great because oscillators exist in many billions years. Thirdly, transmission of energy between oscillators depends on phase relations between oscillations within them. Transmission of energy is absent completely at certain phase relations.

Consider features of interaction of a system of oscillators to clarify a possibility of using these features to accelerate their disappearance. Initially the simplest case of interaction of two coupled oscillators is considered.

Interaction of two interconnected oscillators

A theory of interconnected oscillators is well developed and is used in many absolutely different applications. We present its results used in the further consideration. In the elementary case the following system linear differential equations describes change of complex amplitudes a_1 and a_2 in identical oscillators 1 and 2, respectively, with identical eigen frequencies ω [16]:

$$\begin{aligned} da_1/dt &= j\omega a_1 + jk\omega a_2 \\ da_2/dt &= j\omega a_2 + jk\omega a_1. \end{aligned} \tag{15}$$

Here dimensionless coupling index $k = j\kappa/\omega$, where κ is the coupling index used in [16]. The system (15) has two eigen frequencies

$$\omega_1 = (1 - k)\omega \tag{16}$$

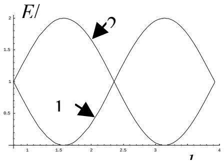

Figure 17. Dependences of

and

$$\omega_2 = (1 + k)\omega, \tag{17}$$

which correspond symmetrical $\{a_1 = \exp(j\omega_1 t),\ a_2 = \exp(j\omega_1 t)\}$ and anti symmetrical $\{a_1 = \exp(j\omega_2 t),\ a_2 = -\exp(j\omega_2 t)\}$ eigen solutions. Any linear combination of these eigen solutions is also a solution of the system (15). Any solution describes beatings which amplitude and phase depend on initial conditions at $t = 0$.

For example, if $a_1(0) = 1$, $a_2(0) = 0$, then $a_1(t) = \cos(\Omega t)\exp(j\omega t)$, $a_2(t) = \sin(\Omega t)\exp(j\omega t)$, where

$$\Omega = k\omega \tag{18}$$

is a frequency of beatings which does not depend on the initial conditions. Since the energy stored in an oscillator is proportional to a square of amplitude of oscillations, then

$$E_1(t) \sim \cos^2(\Omega t),\ E_2 \sim \sin^2(\Omega t), \tag{19}$$

where $E_1(t)$, $E_2(t)$ are energies stored in oscillators 1 and 2, respectively. It easy to see that $E_1(t) + E_2(t) = \text{const}$. Dependences of energies of two interconnected oscillators on time at optimal phase relations are shown in figure 17.

A transfer of energy between two identical nuclei depends on phase relations between oscillations in them. A transfer of energy is absent only in the eigen solutions in which phases are identical in the symmetric own solutions or differ by π; for antisymmetric one. Speed of transfer of energy is maximal, if amplitudes of oscillations are identical, and their phases differ by $\pi/2$. The first condition is valid for nuclei.

The second condition can appear valid accidentally. In general, transfer of energy takes place at any phase difference φ. However the amplitude of beatings can change from zero (when the difference of phases is equal 0 or π) up to maximal. Transfer of energy takes place at any coupling index k but the speed of transfer is proportional to k. It is possible to conclude, that appreciable interaction between oscillators is possible at any distance between them provided that duration of interaction is comparable with the beating period.

$$\tau_b \cong 2\pi/\Omega = 2\pi/(k\omega) = \tau_n/k. \tag{20}$$

As to coupling index k that it is known reliable that k is extremely small. As shown in [16], appreciable interaction between two oscillators with own frequencies ω_a and ω_b, takes place, if the following condition $(\omega_a - \omega_b)/\omega_a < k$ is valid. In this case the difference between own frequencies of any two unequal nuclei is so great, that this condition is not valid. Thus, a noticeable interaction can be only between identical nuclei.

It is necessary to take into account that the nuclei considered as oscillators are a typical “nonlinear oscillating system”. It means that properties of nuclei depend on amplitude of oscillations. In our example energy of oscillations increases in one nucleus by 12 % and decreases in other nucleus in time $0.01\tau_b$. The difference in amplitudes can become so great, that the stationary condition of nuclei occur violated and the system from two interconnected nuclei can pass in a new steady state characterized by a new local minimum of the total energy which is smaller than previous less was. Thus superfluous energy is liberated. For example, there can be a synthesis of two nuclei of deuterium. On the contrary, for heavy nuclei, for example, uranium, there can be a nuclear reaction of division. In any case own frequencies of oscillators after liberation of the excess energy become various and their interaction stops. Thus, any noticeable in action R can be only between identical nuclei.

Ought to note that instable states of a nucleus uses in the nuclear physics for a long time for an explanation of that fact, that a slow neutron can split a nucleus ^{235}U better, than a fast neutron.

Unlike a fast neutron, a slow neutron can be absorbed by nucleus; it becomes instable and disintegrated as a result of this instability. We are going to show that instable states can appear not only under action of slow neutrons, but also as a result of long interaction of two identical nuclei.

Interaction of a set of oscillators

It is simply enough to imagine a picture of interaction of two nuclei located near each another for a long time. But how such picture can be realized? As is seen from (18), (19), the degree of interaction R at the maximal speed of transfer of energy is determined by the expression:

$$R = \Delta E/E_0 = 2\Omega\tau = 2\omega k\tau, \tag{21}$$

where $\Delta E/E_0 << 1$ is relative change of energy in time τ. We have from (21) that R is maximal when product of $k\tau$ is as much as possible at optimum phase relations. The coupling index k can be increased by decreasing a distance r between oscillators. The most radical way to decrease r is to increase density of interacting oscillators.

Seemingly, liquids or solids are the most suitable candidates for realization of great interaction between oscillators because their nuclei are located to each other closer than in gases. However it appears that in these conditions a majority of interconnected oscillators is in a steady state and the difference of phases of oscillations between adjacent interacting oscillators is equal to zero. In this case there is no interaction between oscillators. Interaction of a set of mutually interconnected oscillators is well enough studied in radio engineering as a set of mutually connected oscillators in the form of LC circuits is used in high-quality radio receivers. Nuclei in liquids or solids considered as interconnected oscillators form a specific three-dimensional transmission line in which any deviation from a stationary condition in any oscillator at once begins to propagate in all directions through a chain of interconnected adjacent oscillators.

The more coupling index between oscillators the greater the speed of propagation of the deviations. In other words, oscillators are synchronous among themselves. Certainly, there are some small deviations from steady state because of thermal motions of atoms, but these deviations cannot lead to a sharp increase in amplitude of some oscillators.

Like a random motion of gas molecules can not entail a sharp increase in gas density, small random phase shifts can not entail significant increase in amplitudes of oscillations. Any increase in amplitude of an oscillations entails immediate scattering. Thus, liquids or solids do not permit to accumulate results of interactions because phase relations between oscillators are far from required ones.

Absolutely other situation takes place in a set of moving oscillators presented by atoms of gas at normal conditions. In this case time of collision oscillators is much smaller than time of free movement between two consecutive collisions. Each collision is accompanied by occurrence of a system consisting of two interconnected oscillators. In such system its own frequency can change in a range $(1 - k)\omega < \omega < (1 + k)\omega$ and depends on phase relation between oscillations in the oscillators.

The change in own frequency leads to change of phases of oscillators as compared with a phase of an isolated oscillator with own frequency ω. Change of phases of oscillators can be both positive and negative depending on initial phases between interacting oscillators. The total phase shift appeared as a result of one collision depends on force (k) and time of interaction. The smaller distance between interacting nuclei, the greater phase shift at one collision. Thus, unlike system motionless interacting oscillators where take place certain phase relations between adjacent oscillators, the steady state of a system of chaotically moving and colliding oscillators is characterized by random phases of each oscillator.

It is easy to be convinced, that if phase relations at each collision are random, the probability that favorable collisions considerably prevail above unfavorable ones is negligible small. This

conclusion does depend on neither pressure nor temperatures of gas. Because of this it is useless to try to increase result of interaction by means of increase these parameters. Thus, neither solids nor liquids nor gases can provide significant change in energy of oscillators. Seemingly, our attempts to use features of oscillators for significant change of their energy are fruitless. However non steady states have been not analyzed yet.

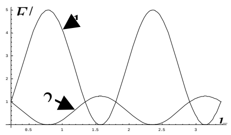

Figure 18. Dependence of energy in 5 interacting oscillators on time: 1

Effect of repeated long interaction

Assume, that gas is compressed up so, that oscillators of gas are densely packed in such degree, that the volume per one oscillator is equal to volume of the oscillator. In such gas an effect which enables to accumulate significantly result of interaction R appears. Unlike gas at normal conditions where each oscillator collides each following time with a new oscillator and a probability of collision in the near future with a former oscillator is extremely small, the behaviour of a oscillator in gas densely packed oscillators is absolutely different. Each oscillator oscillates in an environment of the same adjacent oscillators which do not allow it to move freely. In this case two identical adjacent oscillators can interact many times between themselves and accumulate result of interaction R.

Phases of oscillations in homogeneous gas of densely packed oscillators are random; at least, they are random after sharp compression. In this case the probability that the area where R can be accumulated noticeably is rather great. Really, if oscillator is surrounded by K identical oscillators, the probability that phases of all these oscillators are favorable for transmit of energy to central oscillator is equal to $p = 2^{-K}$. For example, if $K = 6$, $p = 1{,}6\ 10^{-2}$. As the total number of oscillators $N \cong 10^{20}$ cm^{-3}, the number of such areas is rather great.

Generalizing (15) on five oscillators, one of which is located in the point with coordinates ($x = 0$, $y = 0$), and others are located in points with coordinates: ($x = 0$, $y = 1$), ($x = 0$, $y = -1$), ($x = 1$, $y = 0$), ($x = -1$, $y = 0$), we receive dependences of energy oscillators on time, shown in figure 18. It is supposed, that energies of all oscillators at $t = 0$ are identical, and the phase of oscillations in the first oscillator lags behind by $\pi/2$ from phases of others oscillators. As follows from figure 18, the maximal energy in the first oscillator increases by 2,5 times, and the period of beatings decreases by 2 times as compared with figure 17. Speed of increase in energy in the first oscillator at $t = 0$ in figure 18 is greater by 8.9 times, than that in figure 17. It means, that action of 4 adjacent oscillators with favorable phases is stronger by 8.9 times than action of one oscillator

Possibly, it is difficult enough to provide optimal conditions for realization of accumulation from K oscillators and they can be realized only at extremely favorable phase relations. For example, if to admit that the probability of extremely favorable phase relations between two adjacent oscillators is equal $p = 0{,}1$ instead of $p = 0{,}5$ the probability of extremely favorable phase relations in a system from $K + 1$ oscillators is equal 10^{-K}. Thus, the greater K, the more favorable conditions can be obtained, but a probability of such conditions decreases with growth K.

Usually, when any transient processes in some system are considered, a time constant is introduced which characterizes how quickly the system tends to its steady state. From this reasoning ought to introduce a time constant τ_R, which characterizes the time required to a system from a gas of densely packed oscillators with random phases to pass in the steady state when phases of all oscillators are identical.

However before it is necessary to find some mechanism responsible for dissipation of energy in a non-equilibrium system because energy of the system at steady state should be minimal. Action of this mechanism determines value of the time constant. For example, in gases, this constant differs significantly for different mechanisms. In gases it is necessary only 1-2 collisions between molecules for a forward-forward relaxation, 4-5 collisions for rotary-rotary one and about 10^{20} collisions for oscillating-oscillating one [17].

In accordance with (16) own frequency of a system of two interconnected oscillators with synchronous oscillations decreases at nearing oscillators. Then in accordance with Manley-Rowe relations energy of such system decreases. It means that oscillators are drawn one to other. As a result, in liquid or solid, consisting from such oscillators, there are forces of compression that leads to appearance of elastic fluctuations with corresponding dissipation of energy. Unfortunately, the physical nature of these forces of an attraction is not known to us. We can remind only that the physical nature of gravitation forces is not known also. Possibly, these forces can have an identical origin.

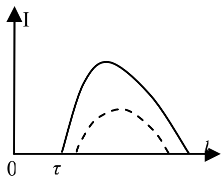

Figure 19. Dependence of the speed of

As follows from presented theoretical consideration the following conditions should be provided for noticeable increase in R. First, compression of gas should be so much strong that molecules of gas have appeared densely packed close together. Secondly, they should remain densely packed for a long time. In the third, duration of transient on compression of gas should be no more τ_R. Summarization of all this three conditions enables to claim that a quickly prepared long-living gas of densely the packed molecules is necessary for obtaining areas where a noticeable increase in R is possible

As the maximal coupling index k_{max} between oscillators is small, areas with noticeable increase in R can be obtained if time of interaction between oscillators is greater than a certain bottom threshold τ_{min}. As follows from (21),

$$\tau_{min} = R/(2\omega k_{max}). \quad (22)$$

If duration of interaction is smaller than τ_{min}, appearance of areas with noticeable increase in R is impossible.

The solid curve in figure 19 shows dependence of the number of oscillators I which energy decreases down till E_{th} at the assumption that gas is compressed instantly at $t = 0$. The curve is received on the basis of following qualitative consideration. Time τ_1 is minimal time, which is required to accumulate the action at an assumption that the oscillator occurs at optimum phase relations with other interacting oscillators. As the probability of such situation is small, the number is close to zero. With increase in time of interaction E_{th} is reached at phase relations which differ from optimal ones a little. The probability of such phase relations is greater and, hence, the number is also greater. At the further increase in time of interaction the number I can start to decrease, because there is an alignment of phases in adjacent oscillators, and the exchange of energy between them ceases.

If compression of gas occurs not instantly, dependence of the number I on time is described by curve shown in figure 19 by dashed line. The following features of this dependence ought to notice. The delay τ_1 after which I becomes different from zero increases because of transients which take place during compression of gas. These transients at which phases of all oscillators are leveled, do not allow to receive optimum phase relations at $t > \tau_1$. The maximum of a curve decreases. Ought to underline, that I is always equal to zero at $t < \tau_1$ and, hence, long compression always is required. If speed of transients is greater than speed of compression, I is close to zero as the system is in quasi steady state where the exchange of energy between oscillators practically is absent.

Thus we can wait a noticeable increase in a speed of radioactive decay in a quickly prepared long living gas of densely packed molecules.

The analysis of the physical conditions in experiments accompanied by nuclear conversions

Meaning simple theoretical conclusions received above, we shall analyze conditions of successful experiments known to us in which anomalous phenomena were observed. It has

appeared that in all experiments quickly prepared long living gas of densely packed molecules took place. Ought to note that the shell of the light bubble consisting of strongly compressed air can appear extremely quickly during a fraction of micro second. There are some experimental confirmations of this fact [18]. It is no wonder because light participates in its formation and makes thousand revolutions in the shell in this time. Thus, physical conditions inside of an AO shell are suitable for increasing radioactive decay. AO shell is, probably, a single object among known ones which provides necessary physical conditions at which time of interaction $t > \tau_1$. Analysis of experimental studies where mention about nuclear conversions takes place shows that AOs are observed in the great bulk of these studies. There is one group of the studies where nuclear conversions are observed but direct mentions about AOs absent. But a quickly prepared long living gas of densely packed molecules is presented in these studies too. Consider results of some experiments.

At first sight, no such gas existed in classical Pons and Fleishman experiments connected with electrolysis of palladium electrodes in heavy water. Really, it seemed so within 14 years. In 2003, as a result 14-years research the following facts [19] have been established. First, areas in which nuclear activity takes place lay on a surface of the cathode, instead of inside of metal as it was supposed earlier. Secondly, these areas exist in dendrites or nano crystals, located on a surface of an electrode, instead of on the very surface. A conclusion has been drawn that the only thing necessary for a nuclear conversion is existence of the small isolated domains of a material. It can be dendrites growing on a surface of the electrode or impregnations in the palladium electrode, or grains of other material on the palladium electrode. Erosive discharges on these inhomogeneities can occur

These conclusions were confirmed in Szpak work [20], where was shown that nuclear conversion is accompanied by occurrence on a surface of electrode of "hot spots" and micro explosions. It was estimated that each micro explosion is accompanied by a nuclear conversion in which from 10^4 up to 10^9 nuclei participate. It is not excluded, that the reason of micro-explosion is disappearance of a miniature ball lightnings have appeared as a result of local erosive discharges. The term “miniature ball lightning” means the same that our tem “autonomous object”. We shall use already accepted term though the term miniature ball lightning is more often used. Japanese investigator Matsumoto [21, 22, 23] repeatedly informed about observation of AOs in conditions of classical Pons and Fleishman experiments

Lewis analyzed surfaces of those cathodes which have been used in successful attempts to carry out nuclear conversion. It turns out that these cathodes, unlike other cathodes, have been undergone to strong erosion [24]. Besides, occurrence of AOs from their surface was observed in a process of nuclear conversion. Similar erosion of electrodes is observed in numerous experiments on AO production by means of erosive gas discharge [25]. Thus, at present time it is authentically established that nuclear conversion in conditions of classical experiment is accompanied by occurrence AOs and, therefore, there is a quickly prepared long living gas of densely packed molecules.

Such gas presents also in cavitation bubbles produced in liquids by means of an intensive acoustic wave. It is known, that pressure in such bubbles at their compression can reach several thousand atmospheres. As was shown in Kladov experiences carried out in 1998-2001, nuclear conversion took place in such bubbles [26, 27, 28]. Analogous experiences have been carried out by Taleyarkhan group in 2004 [29].

Now this group is financed by DARPA. The conclusion that the gas obtained at explosions accompanied by erosion of a material is favorable for nuclear conversion has been confirmed by Ukrainian scientists who used a powerful pulse of electrons with energy about 1 kJ for super compression of substance [30].

It would seem, the gas is absent in Correa experiments connected with production of excess energy by means of vacuum discharges. [31]. However works of other researchers, in particular, Shoulders showed that the vacuum discharge is accompanied by occurrence of so called exotic vacuum objects and transmutation of elements [32]. In reality such objects represent AOs, and their shape where intensive light circulates consists of vapors of metal which has evaporated from the cathode of a vacuum tube. Thus, the gas consists of molecules of metal in this case of. The same is valid for Solin experiments with welding of zirconium in vacuum by electronic beam [33].

By the way, Sholders studies allow to explain existence of ectons which are avalanches of electrons arising at the vacuum discharge [34]. An appearance of an avalanche can explained somehow within a frame of usual representations without attraction of AO but it is impossible to find out reasonable reasons caused a disappearance of an avalanche. As was shown in chapter 2, introduction of AOs into consideration of the phenomena at vacuum discharges enables to explain both occurrence, and disappearance of avalanches, and also the fact of their existence. Introduction of AOs into consideration permits also to explain occurrence of excess energy in Correa experiences because any appearance of AOs is accompanied by appearance of a quickly prepared long living gas of densely packed molecules. The excess energy appears due to acceleration of nuclear decay. Indeed, transmutation of elements has been fixed in Sholders experiments.

R.F. Avramenko has informed about generation of excess energy by means of AOs in a form of so-called great energy plasma formations [25]. In this case AOs were produced by erosive gas discharge in air at normal atmosphere pressure. Urutskoev has informed about a transmutation of elements at explosions of titanic wires at discharge of the battery of capacitors about 50 kJ stored energy [18]. He has marked that the explosions are accompanied by occurrence of "spherical plasma formations". In reality, they are AOs. By the way, the fact of extremely fast occurrence of light bubbles in has been fixed in these experiments in the first time. It has appeared, that at shooting by high-speed video camera a light bubble appears so quickly, that it is absent on one frame, and it has been generated completely on the following frame.

Thus, introduction of AOs into consideration allows finding out some common and explaining seemingly absolutely different experiments. All known experiments on successful realization of nuclear conversions, where either generation of excess energy, or transmutation of elements takes place, are accompanied by an appearance of a quickly prepared long living gas of densely packed molecules.

Some views on order of magnitude constants used above can be obtained from analysis of physical conditions of successful experiments accompanied by nuclear conversions. Since life time of AO is in the interval from 1mks to 1 ms and the lifetime is comparable with the time constant for passing a system of densely packed oscillators in a steady state, then τ_{NC} is in an interval from 10^{-6} up to 10^{-3} s. The beating period is greater by 1-2 orders of magnitude than τ_{NC} and, hence, and τ_b is in an interval from 10^{-5} up to 10^{-1}s.

According to modern representations of nuclear physics "in a nucleus, considered in a form of a drop [35], there are oscillations with the period $\tau_n = 10^{-21}$s and amplitude equaled to 0,1-0,2 radius of a nucleus ". Taking into account that $\tau_n \approx 10^{-21}$ s, we obtain from (20) $k = \tau_n/\tau_b \approx 10^{-20}$–$10^{-16}$. Certainly, these evaluations are only an illustration of how extremely small coupling index can lead to a appreciable result for reasonable time.

Observation of appearing AOs testifies that physical conditions in AOs are favorable for acceleration of nuclear decay. Since the nature of AOs is known, these conditions can be created in laboratory. It is known, that experiments with nuclear conversions are characterized weak reproducibility. Low reproducibility takes place also in experiments on AOs production because a physical nature of AOs was not known for experimenters. Purposeful use of erosive gas discharge allows to eliminate the specified lack and to start purposeful accomplishment of nuclear

conversions. In accordance with one of hypotheses, the Ball Lightning was a reason of Chernobyl tragedy [36], which essentially delayed development of atomic engineering. It is not excluded, that the Ball Lightning will expiate the fault and will play solving positive role in development of absolutely new direction in nuclear energetic which will lead to creation of new cheap alternative energy sources. How the life on the earth will be changed is described by American futurologist Arthur Clark [37].

Possible types of nuclear decays

From the presented consideration follows that interaction of only identical nuclei can accelerate a nuclear decay. Besides, the smaller the difference between the energy stored in a nucleus before decay and after decay the easier conditions for realization of such conversion can be created. What types of nuclear conversions can be carried out by accumulation of interaction between adjacent identical nuclei? It is not difficult to find out a majority of possible decays in which the minimal excess energy takes place. In this case the total number of protons and neutrons is kept after conversion.

Similarly to classical reaction of synthesis of deuterium nuclei

$2\,{}^{2}_{1}D \rightarrow {}^{4}_{2}He + 23.8$ MeV,

We can write, for example, the following reactions

$2\,{}^{27}_{13}Al \rightarrow {}^{26}_{12}Mg + {}^{28}_{14}Si + 3.315$ MeV,

$2\,{}^{63}_{29}Cu \rightarrow {}^{64}_{30}Zn + {}^{62}_{28}Ni + 1.59$ MeV.

The excess energy is determined by the difference in mass defects ΔM between initial and resulting products. In accordance with [38] ΔM for considered nuclei are the following:

ΔM for ${}^{27}_{13}Al$ – 17.194 MeV,

ΔM for ${}^{26}_{12}Mg$ – 16.212 MeV,

ΔM for ${}^{28}_{14}Si$ – 21.491 MeV,

ΔM for ${}^{63}_{29}Cu$ – 65.578 MeV,

ΔM for ${}^{64}_{30}Zn$ – 66.001 MeV,

ΔM for ${}^{62}_{28}Ni$ – 66.745 MeV.

Notice, that the left hand side in the record of reactions begins with number 2. It means that identical nuclei can participate in reaction only. The first reaction with deuterium is reaction of synthesis. However it is impossible to tell about the second and third reactions as before and after reaction 2 nuclei exist. After the analysis ΔM for some heavy nuclei, it is possible to write, for example, the following reaction:

$$2\,{}^{200}_{80}Hg \rightarrow {}^{200}_{80}Hg + 2\,{}^{100}_{40}Zr + 100 M эB$$

This is typical reaction of radioactive decay with generation 100 MeV additional energy. Actually there is a splitting Hg nucleus on 2 identical *Zr* nuclei by means of other *Hg* nucleus that is accompanied by generation of superfluous energy. Certainly, splitting can occur and on not identical nuclei. Thus, there can be a synthesis of nuclei, their splitting, and also transmutation of elements, at which 2 identical nuclei is transformed in various nuclei. Thousands of similar reactions can be imaged. The considered examples are only an illustration. The analysis of possible types of nuclear conversion is a problem of nuclear physics. We would like to note only one obvious conclusion. The smaller life time of a nucleus is the easier to carry out nuclear conversion with such nucleus. Indeed, in this case there are either relatively great radiating losses or/and a small difference E_0-E_{th}. An isotopic conversion is accompanied by small excess energy. What is why a change of a natural isotopic ratio is mentioned often.

It is very pictorial experiments of Urutskoev at explosion of a titanic wire which were accompanied by appearance of AOs. Natural isotopic ratio changed after the explosion as follows. A fraction of isotope Ti^{48} decreased from 72 % up to 62 %, percent of isotopes Ti^{46}, Ti^{47}, Ti^{49}, Ti^{50} increased from 8 % up to 10 %, from 6 % up to 8 %, from 10 % up to 12 %, from 6 % up to 8 %, respectively. Unfortunately, the paper with these data disappeared from Internet. Mention about these reactions is in [40]. Apparently, there were nuclear conversions of the following type

$$2{}^{48}_{22}Ti \to {}^{49}_{22}Ti + {}^{47}_{22}Ti + 3.485\ MэB$$

or

$$2{}^{48}_{22}Ti \to {}^{50}_{22}Ti + {}^{46}_{22}Ti + 0.420\ MэB$$

In the first case one neutron passes from one nucleus in others and in the second case two neutrons pass.

Probably, similar reactions use colonies microbiological cultures in radioactive waste with rather small life time. There is evidence that in such environments transmutation of elements is possible. Besides noticeably increases the speed of radioactive decay [40]. Thus there are neither explosions, nor intensive light, nor any AOs.

"Micro installation" in a form of a bacterium can be imagined which have learned to break a stationary phase relation between adjacent oscillators by sharp relocation of oscillators. As a result, the coupling index between oscillators and their own frequencies change. It causes phase shift of oscillations in these oscillators relative a phase of oscillations in an isolated oscillator. When the phase shift reaches $\pi/2$, the bacterium nears the oscillator with other oscillator having the steady state phase. As a result, the phase shift between these oscillators becomes equal to $\pi/2$. This provides transmission of energy from one oscillator to others. Thus the bacterium accelerates a decrease in energy of nucleus until its energy achieves threshold E_{th} and the nucleus breaks up. Excess energy generated at this process is used by bacterium for ability to live.

As a rule, coupling index between usual nuclei is so small and the difference E_0-E_{th} is so great that the bacterium is not able to provide a necessary decrease in E_0 down to E_{th}. But the situation can be favorable for nuclei with rather small half-life period. There is double usefulness from small half-life period of a nucleus. Firstly, the smaller half-life period of a nucleus the greater the amplitude of wave function outside the nuclei because in accordance with generally accepted notions the square of the wave function outside a nucleus is proportional to the probability of its decay. In this case coupling index between adjacent nuclei is greater than that between nuclei with great half-life period. Secondly, the difference E_0-E_{th} is small enough because the excess energy is small. Radioactive waste with rather small life time contains such nuclei. Bacteria have learned to extract and use excess energy for their life earlier, than the people have. Bacteria have advantage over people because there are no theorists among bacteria who assert that it is impossible.

Certainly, it is very hard work to find out the most suitable new fuel for new alternative sources of energy. On the one hand, it should be a wide spread element with relatively long life so time that it is not dangerous for health. On the other hand, its excess energy at accelerated nuclear decay should be considerable and conditions for production of a quickly prepared long living gas of densely packed molecules should be as simple as possible. Thus, instead of a single nuclear reaction of synthesis of deuterium nuclei which takes place in H-bomb there are a lot of other nuclear reaction which are also accompanied by appearance of excess energy. Possibly, presented above our rough consideration can determine a direction of further investigations. Ought to underline there is no mystics. Indeed, natural radioactive decay is an objective reality. Possibility of changing the speed of radioactive decay is also objective reality. Appearance of excess energy and transmutation of elements are also objective realities. Everything that is required it is to find out a way of using these realities in practical applications.

Conclusion

Extension of processes and the phenomena occurring in a light bubble on nuclei of elements allows to explain the phenomenon of natural radioactive decay. Just as the energy reserved in a light bubble is gradually decreasing and the light bubble becomes instable, energy of a nucleus gradually decreases in time too; the nucleus becomes instable and breaks up. It is shown that such assumption does not contradict reliable experimental data according to which average energy of a nucleus does not depend on time if interaction between nuclei is taken into account. The experimental data confirming these conclusions and testifying that external conditions can influence on the speed of a radioactive decay are presented.

An attempt to find the means allowing to increase speed of radioactive decay has been undertaken. With this purpose the nucleus has been presented in a form of nonlinear oscillator with a definite life time. An interaction of a set of such identical oscillators has been considered. It is shown, that for a noticeable decrease in energy of the some oscillator it is necessary to randomize initially phases of all oscillators, and then to pack these oscillators as quickly and densely as possible to provide condition that the relative positioning of oscillators would be kept in a relatively long time. The derived conclusions can be used not only for realization of nuclear reactions of decay but also for nuclear reactions at which transmutation of elements occurs. It is shown that such reactions could be carried out in the quickly prepared long-living gas of densely packed molecules. Numerous experimental data supporting this conclusion are presented.

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Conclusion

Coming back to the question in a title of the book, we can say that the Ball Lightning is trying to inform people about existence of absolutely new objects and the phenomena, about which nobody earlier knew and suspected even. These are light bubbles of various kinds which size, life time and stored energy can be changed over a wide range. A shell of such light bubbles can be the most various also. It can consist of compressed air, the compressed gas which refractive index is greater than that of surrounding space, a double charged layer. A shell of a light bubble can confine also negative charges.

A series of new physical effects and phenomena has been derived from a mere fact of light bubble existence and analysis of their properties obtained as a result of two centuries experimental investigations. These discoveries are valuable in their own rights and can be used in other practical applications.

It is not excluded, that physical conditions inside of a light bubble are favorable for acceleration of radioactive decay. Therefore the further studying of light bubble properties can have a great practical application in a field of development alternative energy sources on the basis of the energy which accompanies radioactive decay. It is right of readers to judge how close the presented approach to reality. In our opinion the approach is deserving of attention because it enables to explain too much anomalous phenomena. It concerns to behaviour both Ball Lightnings and autonomous objects.

Such puzzles of behaviour of Ball Lightnings as penetration through windowpanes, movement in direction which does not coincide with a direction of a wind, accompany of airplanes and penetration in their salons, radiation of "cold" white light can be explained only on the basis of the considered concept. Numerous anomalies in behaviour of autonomous objects, such jumping from a sheet of a paper, burning a sheet of a foil, gallop on a surface of a table with the sudden termination of a luminescence in any point of a trajectory, behaviour near a vessel with liquid nitrogen and in ultrasonic stream, penetration outside through a hermetically sealed glass tube can be explained only on the basis of the offered concept. It gives confidence to authors in correctness of the chosen approach.

The theory of light bubbles presented in Chapter 3 disproves arguments of opponents that existence of light bubbles contradicts laws of physics. Time is required for general recognition of

the presented approach. Copernicus theory was required about a century for general recognition. We hope that smaller time will be required in our case.

As to relation between Ball Lightning on the one hand and excess energy and transmutation of elements on the other hand, such relation exists objectively as words “Ball Lightning” are often mentioned in combinations with these words. Knowledge of physical conditions in Ball Lightnings and the assumption that these conditions are favorable for acceleration of radioactive decay give much enough information about processes responsible for such decay.

Methods and the means used in nonlinear optics and theory of optical resonators on the basis of waves of type whispering gallery are transferred for the description of the phenomena inside of a nucleus and inter nuclear interactions. Consideration of a nucleus as an analog of a Ball lightning with finite life time enabled to propose a new approach to an explanation of the phenomenon of natural radioactive decay.

Conclusion

As follows from presented approach, there are light bubbles of various kinds which size, which life time and stored energy can be changed over a wide range in nature. A shell of such light bubbles can be the most various also. It can consist of compressed air, the compressed gas which refractive index is greater than that of surrounding space, a double charged layer. A shell of a light bubble can confine also negative charges.

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A series of new physical effects and phenomena has been derived from a mere fact of light bubble existence and analysis of their properties obtained as a result of two centuries experimental investigations. These discoveries are valuable in their own rights and can be used in other practical applications. Time is required for a general recognition of the presented approach. About a century was required for Copernicus theory for a general recognition. We hope that smaller time will be required in our case.